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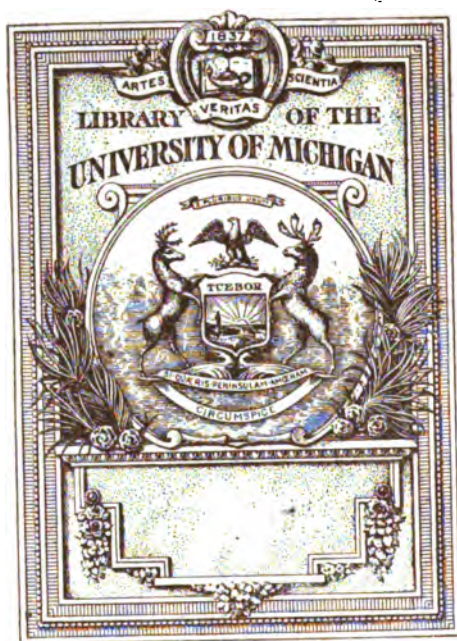
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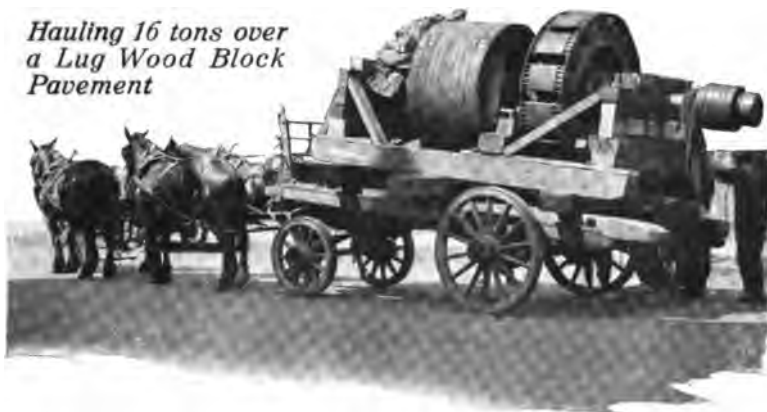
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OF THE
Twenty-Third Annual Convention
AMERICAN SOCIETY OF
MUNICIPAL IMPROVEMENTS

HELD AT
NEWARK, N. J.,
OCTOBER 10, 11, 12, 13, 1916.

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REPORT OF THE COMMITTEE ON STREET PAVING, ON PRESENT PRACTICE REGARDING REPLACEMENT OF CUTS IN PAVEMENTS.

Horace Andrews, Chairman, Consulting Engineer, Albany, N. Y.

The Committee of Street Paving has prepared its report bearing in mind that technical literature is now teeming with papers relative to the subject of street and road building while the transactions of our society will this year contain much that is important relative to methods that are new or are advancements on former well known means of road improvement.

Great difficulty confronts the modern road builder who is called upon to produce road surfaces that will be able to answer the requirements of traffic with horse-drawn vehicles and at the same time be suitable to withstand the strongly destructive action of motor vehicles, especially the very heavy motor trucks of various kinds that are becoming increasingly more common. Much remains to be done before any definite answer can be given to questions relative to lasting qualities and to economy of construction and maintenance.

Your committee has left to the individual writers of papers on road construction the discussion of matters connected with new discoveries or improved methods, and has taken up the one subject of a proper repair to the street surface when the street is cut into for underground work, and a new foundation and a resurfacing become necessary on that account. As viewed by your committee, the subject of municipal improvements, strictly speaking, does not apply to road building and repairing outside the boundaries of cities and incorporated villages. Within these municipalities there are always many underground constructions, such as sewers, water mains, telephone and telegraph wires, etc., which are the means of bringing to the street departments the peculiar problems of making a repair not called for by any ordinary wear from traffic.

Many of the members of our society will readily recall instances where cuttings have been made in good street pavements that could

easily have been avoided by careful planning in advance of the paving work. Responsibility for sewers and water pipes generally rests upon city officials and these attempt to have all pipe laying precede paving operations. The other underground construction is not so easily controlled by the city and it is worthy of remark that in Chicago there has, within the last five or six years, been in operation a board of underground work of public utilities. To quote from *Engineering News* (July 20, 1916), "The object and work of this board is to save the city pavements from avoidable openings." The co-operation of public utility corporations to this end is most earnestly to be desired as here is a case where most manifestly the "ounce of prevention is worth a pound of cure."

When a cutting into a pavement is made, the repair usually involves making a foundation for the pavement by careful back-filling that shall be capable of holding up the pavement to the same level as before removal, or by bridging with reinforced or extra thick concrete the place that has been disturbed, thus depending entirely upon the sustaining power of the adjoining foundation. In this latter method the back-filling of trenches acts merely as a species of bracing to prevent the adjacent soil from being undermined and disturbed, and as a centering to give support to the concrete, a support that will soon vanish with the slightest settlement of the back-filling. This bridging of trenches is comparatively a new method. Dependence upon the supporting power of back-filling at the present time is more customary than the bridging, and it seems desirable to consider both methods of repair as well as other factors connected with the whole subject of proper repair.

To obtain light upon the questions involved your committee prepared a series of questions, a copy of which is appended to this report, and your secretary caused these questions to be submitted to a large number of cities thruout the United States and Canada. So much of importance has been obtained from the replies to the questions that a brief abstract of the answers from those who have replied is appended to our report, while the full replies are available thru our secretary. The thanks of the committee are expressed to those who have, with public spirit, with generous expenditure of thought, and with sacrifice of time furnished answers to our inquiries.

The persons who received the questions were first asked whether their repairs were satisfactory to themselves. A good many did not reply to this question but implied in most cases that they were unsatisfactory, while fully a third of those answering stated candidly that their repairs were not satisfactory.

Considering first the matter of back-filling, it had seemed to the committee that the very laborious task of replacing the back-filling might be lightened by proper power ramming, and an effort was made to get statistics relative to this matter. It appears that power ramming is very little used by the city authorities, tho the public utility companies make more use of power ramming, apparently. Columbia, S. C., states that power ramming was used and it was not found satisfactory. A request for further information regarding the reasons for this reply was answered by Mr. John McNeal, the city engineer, as follows:

The tamping machine with which this city experimented was a lightweight machine, operated by a small gasoline engine. We found that the weight of the tamper was too light to give satisfactory results and also that the machine required not only a capable man to direct its operation but also that it was more expensive than hand tamping. We find that hand tamping under proper supervision will give satisfactory results and, while we are using reinforced concrete slabs over back-filled trenches excavated on paved streets, the supervision of the back-filling of the trench is by no means neglected on account of this construction. The same careful supervision is given these trenches that would be given them without the concrete slab.

As to flushing the back-filling in order to obtain better consolidation, the replies are worthy of careful consideration. The general opinion is decidedly in favor of this procedure when the soil is sufficiently pervious to enable the water to drain away quickly, otherwise the flushing is very injurious and settling may continue for a year or even for many years before the surplus water will have passed entirely out from the back-filled material. Regarding laboratory experiments as to the drainage power of various soils, interesting information is given by John R. Haswell, Drainage Engineer, U. S. Dept. of Agriculture, in *Engineering News* for Aug. 3, 1916, p. 213.

Of course, if power tamping is to be attempted, water flushing cannot be used, but only a slight moistening may be permissible.

Most of the power tamping seems to be in such work as filling under railroad ties and around pipes. The only extensive power-tamped back-filling brought to the attention of your committee is that between the retaining walls of the Connecting Railroad's bridge at Hell Gate near New York (see *Engineering News*, Jan. 13, 1916, p. 68, lines 7-15). Mr. G. Lindenthal, the chief engineer of the East River Division of the New York Connecting Railroad, writes, in response to a letter of inquiry from your committee:

I take pleasure to give you herewith some additional information on the compacted earth fill as used for our embankments between retaining walls.

The material used was largely sand and gravel with some loam, and was well compacted in its natural state, standing with almost vertical slope.

This material was spread between the retaining walls in layers 12 inches thick. It was then compacted with Ingersoll pneumatic back-fill tampers. The 12 inches of loose material compacted to about 9 inches.

The volume of packed material in the fill is only about one-half per cent. greater than the volume of the same material in its natural state before excavation. Water was used freely in tamping. The fill has been placed in the summer and fall of 1914, and so far no appreciable settlement of the fill has been observed.

A clause of the specification is as follows:

Materials for filling shall be deposited by spreading evenly in layers not to exceed 12 inches in thickness and having a crown of 12 inches at the center between the retaining walls. The layers to be thoroly rammed and compacted with rammers weighing not less than 20 pounds per square foot of area. Water shall be used in the compacting as directed by the engineer.

Attention may be called to the replies from Pasadena, Cal., where the use of a 15-ton roller is referred to, for consolidating the material in the back-fill. This is the only place reporting this method of consolidation. In very many places the crossing of the trench by pipes, water, gas and sewer, which would be much in jeopardy from the use of a heavy roller, would make that means of packing trenches inadvisable.

It is the consensus of opinion from those furnishing replies that all of the repair work should be done by the municipality thru its

own trained workmen, but in some cities exception has been made in favor of those public utilities which are so much in the habit of making cuttings that they may keep a force of trained men for this purpose, but even then it is urged that strict city supervision should not be dispensed with. Much of the trouble found with repairs is attributed to the class of workmen who make the cuttings, back-fill and repairs to concrete and pavement. Skilled men paid by the day by the municipality and employed exclusively on repair work are preferable to all others for insuring uniformity of excellence in cutting-repairs.

It is the practice in every case reporting, not to keep any account of the original order or arrangement of stone blocks or bricks, but they are replaced in accordance with the judgment of the paver.

In replacing stone block pavement the personal observation of the committee has shown that frequently the blocks are put back with joints wider than those originally existing. Many stones for which no place can again be found are therefore removed from the street.

Most of the cities replying state that joints in block pavements are filled with cement grout, but in some cases where traffic is heavy, a bituminous grouting that will enable traffic to pass over the pavement very soon, has taken the place of the slow-setting cement grout at repaired places.

The matter of withholding traffic from recently repaired work seems to be a fruitful source of trouble and it is evident from the replies from some cities that the original care in getting a thoro set to both the concrete base and the cement grouting, by allowing a period of some ten days (see proceedings of 1915 convention, pp. 402 and 455) to elapse before turning on the traffic, is not taken with their repaired work. In some instances it is thought that by covering the newly-made repair with earth to the depth of a few inches, traffic may safely be permitted and that setting of concrete and grout will then go on unimpaired. It is very doubtful whether a shorter time of setting than seven to ten days will enable any repair to approach the original pavement in its solidity and general excellence.

Many cities now seem to have concrete foundations for their pavements and it is well known that thoroly set concrete foundation will support a large area of pavement even where the earth base is weak in spots. This strength of the concrete foundation has led some engineers to follow the practice of bridging any soft place, such as that made by digging a trench, with concrete that will carry the load to the adjacent firm soil. Such concrete is either made of unusual thickness or, more generally, is reinforced with steel (see report of Am. Soc. Mun. Impts. for 1915, p. 407, and answers to inquiries appended hereto).

Judging from the answers received the reinforced concrete bridging gives very satisfactory results and enables the surface of the replaced pavement to be brought to the same place as that of the adjacent pavement without "mounding up," as is so frequently done in the case where the support of the concrete base is either non-existent or has been destroyed.

In Buffalo, N. Y., brick or stone pavement is left a little higher to allow for compression of the cushion, but such compression is not more than $\frac{1}{4}$ to $\frac{1}{2}$ inch and is a usual allowance in all new work that is to be consolidated by rolling or ramming. A possible disadvantage of the concrete bridging is referred to in the reply from Toledo, Ohio, where mention is made of "the roar that is apt to result from rapidly moving steel-tired vehicles passing over the hollowed space beneath the paving."

It seems a rather unfortunate solution of the problem of street repair of the nature now being considered, that the earth foundation should be abandoned as of no use in supporting the replaced pavement, but there is good reason for advocating the use of a bridging of the soft space resulting from a cutting, with reinforced concrete.

The cost of a series of relayings of pavement can hardly be less than that of a good continuous beam of reinforced concrete, while the constant annoyance from interrupted traffic, etc., at each repair is hardly measurable in money value. Moreover, repeated relayings are highly injurious to block pavements, due to the chipping of the corners and breakages.

Attention is called to the reply from Mr. Fancy, relative to work

in the Boro of Queens, New York city, thru the courtesy of Olmsted Brothers, where it is stated that "the concrete roads seem to be the easiest to repair and on account of the many service connections to the houses, that is, sewer, water and gas, it is thought that the concrete road was the best for development work."

It may be found true that a repair can be made to a pavement made entirely of concrete, both as to base and surface, by comparatively unskilled labor, that will compare favorably with repairs where skilled labor is needed in block-paved streets. Delay must be occasioned to traffic owing to the necessity of proper setting of the concrete but the time of blocking of traffic would be somewhat lessened in the concrete paved street from that required where cement grout must also have time to set.

With bituminous pavements, as is well known, excellent repairs can be made where a concrete foundation is used and the usual precautions are taken to insure its proper setting, but a reinforcement of the concrete would seem very advisable in the case of recently filled trenches, even where all possible precaution has been taken with the back-filling.

It seems to your committee that with ordinary methods of ramming the back-filling it is doubtful whether a pavement can be laid over any recently opened trench as well or as economically as is possible with a strong reinforced foundation. Of course, an opportunity must be afforded this reinforced foundation for as thoro setting as in the case of new pavement.

Power ramming does not yet seem to have been thoroly developed and made as economically possible as it may reasonably be expected to become when more inventive effort is directed to its need. Certainly the heavy labor of tamping back-filling may well be supplemented by proper use of power as in so many other branches of industry.

QUESTIONS RELATIVE TO STREET PAVEMENTS NECESSITATED BY
CUTTING FOR GAS, WATER OR SEWER PIPE, ETC., WHERE
PAVEMENT SURROUNDING CUT IS IN GOOD CONDITION.

Are your street repairs satisfactory to you, and if not, in what respect can they be improved?

Replies to questions are sought for the information of the Committee on Street Paving of the American Society of Municipal Improvements.

The information obtained will be presented to the society in the committee's report, as an aid to formulation of proper methods of repair, enabling the entire paved area of a city to be preserved in good and uniformly satisfactory condition.

Answers to the questions are sought in narrative form, but following the order of the questions and replying as nearly to the questions as may be practicable, while adding any facts that may lead to better knowledge and better work in respect to repairs.

BACK-FILLING.

1. What is the character of the soil removed in making cuts for pipe laying repairs?
2. How is soil replaced and consolidated? Have you used power ramming at any time?
3. How large a percentage of the material removed is returned?
4. Is back-filling at any time made of material brought to replace soil dug out and, if so, is resulting work improved to a noticeable extent, and at what cost?
5. Is flushing of back-filling with large quantities of water permitted and advocated, if so, what is nature of soil so flushed and does back-filling subsequently settle and carry the pavement with it, and for how long a period does settling continue?

WORKMEN MAKING REPAIRS.

6. Is the back-filling of trenches made with careful supervision as to tamping, etc?
7. Are repairs made by workmen specially trained?
8. Are the workmen under city pay, and if so, on what basis are they paid?
9. Are repairs made by plumbers, gas or water companies or others merely acting under general municipal regulations?

STONE-BLOCK AND BRICK PAVEMENT WITH SAND OR CONCRETE FOUNDATIONS.

10. In replacing blocks is care taken to preserve the order originally obtaining, or are blocks removed without sorting and then

replaced according to judgment of the paver, with no attempt to preserve original order?

11. Are all the blocks that have been removed, returned?
12. How are the joints filled after paving?
13. Is the repaving brought to the original surface or level, or is the repaving mounded up to allow for settling of trenches?
14. How many relayings of pavement are required before all settling disappears?
15. Have you any brick pavement without concrete foundation, if so, with what are the joints filled? If bricks are broken in removing, are any broken bricks returned in the relaying?
16. Is concrete foundation reinforced at any time after repairs, if so, how is it done? Is any of material of old concrete used in making concrete foundation for repaired pavement?
17. For how long a time is the concrete allowed to set before pavement is replaced?
18. Is a sand cushion used, or a bedding of cement mortar?
19. How are the joints of the repaired pavement filled?
20. For how long a time is the repaired pavement blocked from traffic? Is blocking effectual and the repaired pavement actually preserved from all traffic while blocked?

REPAIRS TO BITUMINOUS OR CONCRETE PAVEMENTS.

21. What precautions are taken to secure a good bond with the existing pavement at the sides of the cut?
22. Are any portions of the old pavement that has been removed used again in making the repair?

WINTER REPAIRS.

23. If a cutting has to be made while the ground is frozen, what kind of back-filling and repaving is done?

Abstract of replies from cities to questions regarding repairs to cuttings in street pavements.

The cities are arranged in accordance with their population.

BUFFALO, N. Y. GEORGE H. NORTON, MAY 22, 1916. POPULATION, 423,715.

Repairs are in general fairly satisfactory, altho they might be improved by better control over the work done by plumbers. Franchise work on re-

pairs is under supervision, but on plumbers' work the inspection is only nominal as the inspector usually visits the trench to see the pipe placed and then again after the trench is filled.

In two-thirds of the city there is heavy clay, not easily replaced, in the remainder of the city there is sand, loam and rock, which give comparatively little trouble. There is hand ramming only. In outlying streets the back-filling is often flooded where it is not expected to lay a pavement in some time. Except with clay all the back-filling can be replaced. Sometimes new material is brought and this costs \$1.00 to \$1.25 per cubic yard.

Flushing is only effective in sandy soils or in some rock trench where the finer material is washed down into the coarser rock. Settlement in a trench may continue for a number of years, but must take place after the first winter.

Some of the labor is trained and the city does comparatively little of this excepting in the repair of its sewers and water mains where city labor is paid for at the rate of 25c per hour. Concrete foundation is generally replaced by city men or by franchise companies, or by contractor under maintenance bond. Old blocks are not sorted but replaced in repaving by judgment of the paver. With bricks, where bricks removed have no lugs, adhering mortar makes it impossible to follow the old course and occasionally a course must be broken to fill in. Cement filler in general use, but on heavily traveled streets a bituminous filler is used as better than keeping traffic off the cement filler. Brick or stone is left a little higher to allow for settlement, not of the trench but rather that due to bedding in the cushion, the general rule is on block stone from $\frac{1}{4}$ to $\frac{1}{2}$ inch and about $\frac{1}{4}$ inch in brick and asphalt, the asphalt left high for compression allowance.

In exceptional cases reinforcing has been used but not enough to establish any general rule. On large trenches we hold the concrete bed from 7 to 10 days before placing the brick or stone but on small cuts the brick or stone are replaced immediately over the soft concrete and usually covered with a layer of gravel or sand. Cement mortar bedding has been used in exceptional cases, in important trenches the grout is held from traffic for 7 to 10 days as stated, but where traffic is heavy bituminous filler is used, or the protecting cover of earth, to give as good protection as possible. Old foundation of natural cement is well broken up, screened and old stone usually used for new concrete, and this same plan used in repaving streets. In freezing weather frozen material is discarded and filling with cinders and on heavy traffic streets the cut is temporarily repaved with old common stone, placed in the sand or cinders until permanent repairs can be made.

TORONTO, CANADA. R. C. HARRIS, MAY 25, 1916. POPULATION, 376,538.

The soil is generally from clay to gravel, E. & W. portions being nearly all sand and gravel with a good deal of clay in central and northern portions. Hand ramming in layers 6 inches deep. Power ramming has been experimented with. Percentage of material replaced, unknown. Only rarely has soil to be brought to replace material dug out. Water flushing is permitted in pervious soils with excellent results, and a great deal of difficulty in subsequent settlement has been avoided in this way.

Water flushing has been attempted in streets, unimproved, where a number of years previously sewer had been laid and it was thought that final settlement had been attained, yet with the water flushing the trenches settled. No repairs are made to the pavements by plumbers or any of the public utility companies, altho the companies may make the cut and after having installed their service attend to the back-filling. Block order originally obtaining is not preserved.

Joints are filled with cement grout except where travel is heavy and then paving pitch is used for jointing. In nearly every instance we can cement-grout the joints in the brick pavements. We endeavor to have the surface level with the adjoining pavement. At times repairs settle and require renewing, it is exceptional to repair twice, however. Bricks on sand have not often been disturbed but where this has been done we have used concrete base for replaced bricks. No reinforcing, or using of old concrete materials. Seven days allowed for hardening of concrete replaced, then bricks are relaid and grouted and 3 or 4 days more allowed before traffic is put on. Bituminous pavement repairs do not present as much difficulty, we cut back the surface to get a clean, perpendicular edge, paint with liquid asphalt and the asphalt mixture is then replaced to the thickness of the surrounding pavement and rolled. Old asphalt has been reheated and mixed with fresh A. C., and then used for repairs, but this practice has not been continued generally.

owing to inadequate plant. In winter cuts the soil taken out is replaced and the pavement repair is not made until such time as the frost has come out of the ground and proper consolidation has taken place.

BORO OF QUEENS, N. Y. CITY. C. B. FANCY. POPULATION, 224,041.

(This reply is from the Chief Engineer of the Sage Foundation Homes Co. and relates only to the work of that company.)

The soil is yellow clay 4 feet to 15 feet deep, over sand. In some cases there are boulders, not over 1 cubic yard, in some places hardpan. No power ramming. In every case we have returned 100 per cent. of the material removed. Improper material, such as loam or vegetable matter, is replaced by sandy clay, the work is thereby improved and the extra cost is simply that of material and hauling, from 20c to 30c a cubic yard. We water-flush wherever we can and have not noticed any case where the pavement has settled. Back-fill is made by our own workmen, except with gas trenches. Specially trained workmen, paid by the hour. Gas company does careful work but the Sage Company allows six months before replacing the pavement. Have had no repairs to stone or brick pavements. Concrete pavement foundations are not reinforced. Repairs in concrete pavement, slopes are made to sides, care being taken that no concrete is fractured along the edges, these edges are painted with neat cement and the concrete then poured flush with the old pavement. I do not know of any better way of repairing the streets, so they are necessarily satisfactory to me. The concrete roads seem to be the easiest to repair. On account of the many service connections to the houses, that is, sewer, water and gas, concrete roads are thought the best for development work.

KANSAS CITY, MISSOURI. L. R. ASH, MAY 17, 1916. POPULATION, 248,381.

Soil generally clay, stone and shale. Tamping by hand only. Flushing used. Ninety per cent. of material replaced. With rock-cutting new material is required to some extent. Sewer cuts back-filled have a large quantity of water in flushing the back-fill, even if the soil is clay. Back-filling generally settles and carries the pavement with it, settling continues for long periods. No specially trained men for repairs. An inspector under city pay is on the work. Repairs are made by plumbers, companies, etc. Blocks are removed without sorting and replaced by the judgment of the paver. Sometimes not all of the blocks removed are returned. Joints generally filled with cement grout, almost universal of late. Pavement is brought to the original surface. As a rule at least two repavings are required before settling disappears. Concrete foundation is never reinforced at any time. Old concrete bases are frequently broken up and the material cleaned and used again in new pavement or in repairing pavement. Concrete is allowed one week to set before pavement is replaced. Sand cushion is used and the joints are filled with cement grout. An attempt is made to block traffic for one week at least, the blocking as a rule is effectual in new work but in the case of repairs the blocking is not effectual and the traffic is generally on the repaired portions of the street within a day or two after the repairs are made. Old asphalt removed is not used again in making repairs. Winter cuts are filled with old frozen material and warmer weather awaited before the final back-fill and repair.

LOUISVILLE, KENTUCKY. D. R. LYMAN. POPULATION, 223,938.

The soil is a compact yellow clay, a loamy clay or pure sand. No power tamping has been used but with clay hand tamping is used and with sand or loamy soil water flushing is used. Ninety-five per cent. of clay is returned and with sand about 98 per cent. Water flushing is more satisfactory for sand than tamping but some trouble is met with from settling which sometimes continues for a period of from 4 to 6 weeks. Joints are filled with Portland cement grout. Pavement is brought to the original level. Usually not more than two repavings are required but if found necessary more repavings are used. Concrete foundation is not reinforced. Materials in the old concrete are used in making concrete foundation after breaking and forking.

Wherever possible the pavement is replaced the same day as it is removed. Pavement is blocked from traffic for two days, but is heavily covered with sand to absorb shocks after the barricades are removed. The blocking is effectual.

TOLEDO, OHIO, G. A. CRATTON, POPULATION 168,497.

In the majority of cases the repairs are not satisfactory for the reason that the earth supporting the paving is not settled all that it will, therefore, after its settlement there is nothing to support the pavement except the

strength of the paving itself. The obvious is (1) See that the earth is compacted all that it ever will be before the paving relayed; or (2) Reinforce the concrete base, if there be one, with steel, sufficiently to bridge over the trench, this latter method is objectionable on account of the roar that is apt to result from rapidly moving steel tired vehicles passing over the hollowed space beneath the paving.

Flushing with large quantities of water is desirable, both as to cost and as to results, provided that the material being back-filled is of a sufficiently sandy character to allow the water to escape quickly, otherwise the water escapes but slowly and permits the paving to settle any way. If the ground is nearly impervious better results are obtained with tamping and slight moistening of the back-fill.

MEMPHIS, TENNESSEE. J. H. WEATHERFORD. POPULATION 131,105.

The soil is yellow clay. Repairs are largely handled, in fact, almost exclusively, by the city, and while the results are not as good as we might like, they, generally speaking, are very satisfactory.

The yellow clay is really ideal for back-filling. Never use power ramming. We generally replace all material except where very large pipes take too much space, and with small pipes we sometimes have to haul new material extra.

Flushing of the back-fill is generally not permitted and has not proved satisfactory, but in a great many cases we back-fill one to two feet above the top of a pipe and puddle this, then throw in dry dirt to take up the excess of the water and replace the balance of the dirt by tamping.

Back-filling is generally done by workmen thoroly conversant with that kind of work. All repairs are made by the city forces. Inability to remove the old grouting makes it necessary to use practically all new material—blocks, etc. If grout has been used originally we grout with repairs. Repaving is not mounded up, but the original surface used. There is no reinforcing, but the old material is put into the back-fill and new concrete is then used. A week is allowed for the concrete to set, but if immediate use is necessary bituminous concrete is used. An endeavor is made to block off rejointed pavement for a week, but this causes much trouble and grouted pavements are the source of much trouble.

SPOKANE, WASHINGTON. MORTON MACARTNEY. POPULATION, 104,402.

The soil is generally rock and a gravelly soil mixed with loose rock. Soil that compacts most readily is preserved and material less desirable is hauled away. In solid rock from 35% to 45% is thus wasted, in gravelly soil and rock from 20% to 35%. We have no requirement that makes it necessary for a contractor to fill with other material than that taken from his trench. Little water flushing is done, and where it is done the soil and back-fill subsequently settles a considerable distance on each side of the trench, and this settling usually continues for a year after the trench has been back-filled. The city supervises the back-fill whether it has done the excavation or not. City operates its own paving plant and does the bulk of paving repair work. The city has little stone block or brick that has been disturbed by excavation. The usual methods of repair are used with bituminous pavements, but no portion of the old pavement removed is used in these new repairs. No frozen ground is allowed to be used in back-fill in winter and pavement is not replaced till warm weather prevails.

HARTFORD, CONNECTICUT. LEON F. PECK. POPULATION 98,915.

Soil is clay. Hand tamping is used with the clay cut into fine pieces and tamped, sometimes mixed with sand and crushed stone. Power tamping has been used by one of the public service corporations. Sand and crushed stone brought to replace material removed give good results. Some supervision only with the back-filling, which is done by ordinary labor, and pavement repairs are made by city men or city contractor. In macadam, some repairs are made by the city men and some by those making the cut. With stone blocks no attempt is made to preserve the original order of the blocks. Granite blocks are grouted with cement. The pavement is left flush with the adjacent pavement. Generally, temporary pavement is first used for a few weeks. There is one block of brick pavement now covered with sheet asphalt, settlements are continually taking place. No reinforcement is used. Old concrete is not used for the final repairs. Concrete is allowed to set from one day to two weeks. Where pavement is replaced the traffic is diverted for a few days. There is no cement bedding for blocks. Cement grout is used for refilling repaved joints and five days blocking is attempted, but

blocking is not always effectual. No old material is used in repairs to bituminous or concrete pavements.

For winter repairs we back-fill with crushed stone and sand. Cement concrete is laid temporarily, flush with the surface.

HAMILTON, ONTARIO, CANADA. A. F. MACALLUM. POPULATION, 81,969.

Repairs are not quite satisfactory. We have decided to remove the concrete base for 12 inches on each side of the excavation and use reinforcement in replacing concrete.

Soil is gravel and sand, shale, red and blue clay and sandy loam. Hand tamping is used, power tamping was used in 1914. Frequently all of the material removed is replaced, no new material is brought. Flushing is permitted in sandy loam soil where the water drains away quickly. If so used with clay the soil remains spongy for a considerable time. Back-filling is done by the municipal companies doing the excavation, but the foundation is replaced by the district foremen of the city and the cost is charged to the company or contractor. With bricks on concrete, setting is allowed for two or three days before bricks are replaced, and for ten days or two weeks after the bricks are replaced. Dry cement mortar cushion and cement grout used. New material is preferred for concrete. Winter cuts remain unpaved till spring and at all times are allowed to remain open for some time.

WILKES-BARRE, PENN. B. K. FINCH. POPULATION, 67,105.

Soil is loam. No power ramming. Ninety per cent if the material is returned in back-filling. Repairs are made by workmen specially trained and under city pay at rates of \$2.00 to \$3.50 per day. All joints in blocks are sand filled. Relaying once, sometimes two or three times. Pavement repairs are not blocked at all from traffic. There are 48 miles of paved streets, all asphalt and brick. Concrete base is cut back to leave a shoulder and this helps to keep the cut from settling.

ERIE, PENNA. E. E. BRIGGS, CITY ENGINEER. POPULATION 66,525.

All repairs to cuts are made by the city, but permits are issued to corporations under bond. Temporary repairs are made by replacing old materials soon after the trench is closed by roughly replacing stone, brick or sheet asphalt, the latter being cut out in small squares. Work is performed by unskilled labor. All trenches are supposed to be well tamped. In case a temporary pavement settles, as it usually does once or twice, the city force places additional filling and relays the bricks, the cost of which is added for final repairs on the bill. Final repairs are made by skilled labor and made to conform to the material and grade of the surrounding pavement. Freshly mixed material is always used in repairing a sheet asphalt pavement. For old asphalt pavements a cheap mixture is used consisting of 3/5 binder and 2/5 topping. Cement grouted pavements are protected for one day by fencing, then covered by three inches of soft earth or sand saturated with water and then opened to traffic. After over ten years of experience in maintaining pavements I am convinced that the most satisfactory plan is for the city to make its own repairs.

CHARLESTON, SOUTH CAROLINA. J. H. DINGLE. POPULATION 58,833.

The repairs are not yet absolutely satisfactory, altho much improved since the adoption of a regulation that all back-filling must be done by city employees. The soil is sand, and sand with a small amount of clay over old marshes that have been filled with sand and mud. Hand ramming is used, no power. All material is generally returned, with small pipes. With bad material mud for back-fillings is brought to replace the same. Large water-flushing is not advocated, but dampening of the material in layers is practiced. City hands do the back-fill under city foremen. The same men are employed, so as to become expert in the work. There is a charge made to plumbers, etc., by rate of cubic yards removed. The order of blocks is not preserved. Repaving is left slightly high, or "stiff," as the pavers call it. Generally after two relayings about a year apart the settling disappears. In some cases the first repaving holds. Concrete foundation is not reinforced in making repairs and old stuff is not used again. Concrete is allowed three days setting before wearing surface is put on, the repaired pavement is opened to traffic as soon as completed.

PAWTUCKETT, RHODE ISLAND. GEO. A. CARPENTER. POPULATION, 51,622.

Repairs are unsatisfactory. Engineering department has no oversight

or jurisdiction in the matter, and all cuts and repairs in the pavements are made by those cutting, individuals, etc. The back-filling is ordinarily made by a laborer and has no supervision by the city. There is no stone pavement on a concrete foundation and very little brick pavement in the city. The whole question of street repairs is in a rather unsatisfactory condition.

BINGHAMTON, N. Y. J. A. GILES. POPULATION, 48,443.

Soil is mostly gravel, in some places is hardpan. The back-filling is in 9-inch layers and hand tamping only used. About 90% of the material is returned. In hard-pan regions the material removed is replaced by gas-house cinders for about three feet above the pipe at a cost of 30c for a yard and a half. Where gravel exists the flushing with a moderate amount of water is permitted. There are no noticeable settlements in the pavement for the reason that the old shoulder of the concrete base is cut back about 9 inches and have used expanded metal extensively to reinforce the new base. There are no specially trained workmen and repairs are made by many parties. No attention is paid to sorting the blocks to keep the original order. Winter repairs are made with sand jointing, and this is replaced in warm weather. Pavement repairs are brought to the original surface. No old concrete is allowed in a new base. Concrete is blocked from traffic in summer for 48 hours, bricks are laid, grouted, barricaded for sufficient time and heavy bed of sand placed over it when traffic is resumed. In very cold weather, when the ground is frozen for two feet or over, the old material is allowed to be used if not frozen in lumps, to within two feet of the surface, cutting is then brought to grade with cinders and allowed to remain in that condition until spring conditions allow new pavement to be laid. There is some difficulty in keeping this cinder fill from being thrown out by automobiles.

PASADENA, CALIFORNIA. E. P. DEWEY. POPULATION 30,291.

Soil is black adobe and brown clay to sand, gravel and boulders. Except in clay and adobe, soil is replaced with a generous amount of water, heaped over the ditch, allowed to partially dry out and then made compact by the use of a 15-ton roller, or by driving a loaded cart along the trench. In case of clay or adobe hand tamping with a little water is required. Power ramming has been used but discarded because the road roller appears to give equally good results at less than half the time and expense. With flooding great care is necessary to avoid softening the ground beneath the uncured paving, causing settlement along the sides of the ditch. The subject is one of great importance and probably has never yet been satisfactorily settled. There is no careful supervision, the parties making the trench throw back the earth, flood the same and leave it well rounded up. After allowing time for partial drying out the street department attends to final rolling and replacing of pavement. We have no stone block and very little brick pavement, and that has never yet been broken into. There is no frost.

NORRISTOWN, PENNA. S. CAMERON CORSON. POPULATION 27,875.

Repairs are not satisfactory. Hand ramming only is used in 6-inch layers, no flooding is permitted. I have had considerable experience with ditches that have been flooded or flushed, and in every instance, excepting sand, the result has been that the ditch was never ready for repairing, it was always too soft and spongy; concrete replaced had to be torn up and the pavement relaid. We now try making a slab of concrete to bridge over the trench space. If such a concrete slab is used, extending from 6 in. to 1 ft. over the edge of the side of the trench the pavement may be laid on the same cushion level, if not, a slight crown is permissible. I do not approve of such crowning, as it usually makes two holes, one on either side of the raised crown. Trolley cars should be kept off the streets, passengers being transferred by check, in which case the results are better than when the cars are allowed to pass over the new work.

COLUMBIA, SOUTH CAROLINA. JOHN MCNEAL. POPULATION, 26,319.

The soil is sand and clay. Back-fill consolidated by hand ramming and flushing, power ramming was tried and proved unsatisfactory. Practically all the material removed is returned. A small quantity of water is used and tamping then used. Large quantities of water are apt to form tunnels in the trench.

In repaving trenches over excavations on paved streets the concrete foundation is removed for a distance of about 12 inches on either side of the excavated trench, and after the back-filling is completed the concrete

base is replaced with a reinforced concrete slab of sufficient strength to carry the surface load in case of settlement of the trench. This plan, while a trifle expensive, has been found most satisfactory, no settlements having appeared over trenches resurfaced in this way. The original order of blocks before removal is preserved. The repaving is brought to the original surface, as it will not settle. Concrete is allowed seven days to set.

MOLINE, ILLINOIS. LYLE PAYTON. POPULATION 24,199.

Yellow clay soil, which can be readily replaced and with hand ramming only. Occasionally the refilling it with sand or cinders. Water flushing is not used, but tamping preferred. Special men who devote all their time to the work are employed; are employed by the city and none by plumbers, gas or water companies. There are no pavements but brick and sheet asphalt, relaid to conform to the original surface of street. In general we have no trouble with settlement. Brick pavement without concrete foundation is relaid on sand and joints filled with sand. If occasion demands the concrete foundation is reinforced with No. 29 wire mesh.

RICHMOND, INDIANA. F. R. CHARLES. POPULATION 22,324.

Repairs are very seldom satisfactory. It is extremely difficult or almost impossible to replace a pavement as good as before disturbance. Soil is clay, loam, gravel, sand and rock. In all but the rock we are generally able to replace all material removed. Occasionally, in case of rock, new material is used for back-fill instead of the rock, with good results. Flushing with water is permitted and in most cases is satisfactory. Even after replacing all material taken out trenches will often settle further, and I have had cases where this settlement developed after six or seven years. Men trained for the work are employed by the water company but not by others, and with these the results are not so good. Water works company has a power tamper which is an advantage in some localities, although even after thoro tamping flushing with water will cause further settlement. Repairs are not made by municipal men. No special effort is taken to maintain the original arrangement of bricks. Cement grout is used in filling joints even with pavements that have soft fillers on original pavement. We prefer not to round up the pavement, in case of further settlement it must be taken up and relaid. This is frequently done at least once. In winter and in bad weather the trench is tamped and the bricks replaced temporarily, using a sand filler, until settlement is completed or weather conditions permit the final relaying. Concrete foundations have at least 24 hours set before laying bricks and the trench is preserved from traffic. In busy streets this is so difficult that we often protect it with 2 to 12 inches of clay and then allow the traffic to go over it.

WAUKEGAN, ILLINOIS. M. J. DOUTHITT. POPULATION 16,069.

Soil clay mostly, but some loam. Replaced by flooding with water, no ramming being ever used. About 90% of the material is replaced. In making a cut thru pavement we refill with sand which costs about 50c per cu. yd. The flushing is good, however, and very little settlement occurs and that takes place within a year. Back-filling is usually by plumbers and is not satisfactory because of lack of inspection. No reinforced concrete ever used. About two days allowed for concrete to set before replacing the pavement and no blocking off from traffic, which is let on as soon as the sand filler is put on the bricks.

PITTSBURG, KANSAS. L. E. CURFMAN. POPULATION 14,755.

Clay soil. Hand tamping and all material removed is replaced. Flushing is only permitted on extensive works and does not give permanent results; time must be allowed for the settlement to occur, after which more material is added and tamped to bring the filling to grade. This is done before the pavement is replaced. Back filling is not carefully supervised, workmen are not in city pay and are not specially trained. Repairs are made by plumbers, companies and others under city regulations. In relaying double-course brick pavements the two courses are kept separate and relaid as to original order of courses. Joints are filled with sand. City ordinance requires the surface to be brought to the original level. We have more trouble in enforcing this provision than any other. Workmen, before the passage of the present ordinance, were accustomed to crown the pavement over the ditch to allow for settlement; some of them still persist in this practice. Reinforcement is used in special cases, such as wide or deep ditches; it is of triangular mesh. Concrete is also made thicker for the base than ordinary. The old concrete is only used in the back-filling. Concrete is allowed three days to set in ordinary weather, longer in cold weather, joints are filled with sand. Repaired pavement is kept from traffic for three

days or longer by not replacing the bricks until the concrete is set, but piling them beside the trench they make an effectual blockade. The copy of the ordinance enclosed provides that the "filling shall be tamped thoroly in 2-inch layers with a tamper weighing not less than one pound per square inch of tamping surface."

Two-course brick work removed is replaced with a 5-in. bed of concrete in place of underlying course of bricks, and this 5-in. bed spans the trench and laps 9 inches on each side.

FARRELL, PENNA. J. FRED THOMAS. POPULATION ABOUT 10,000.

Repairs are not satisfactory. They can be improved by making repairs under supervision of the street commissioner. Practically all of the material removed is replaced. Flushing of the back-fill with large quantities of water is permitted. Soil is clayey. It settles slightly after the flushing for a short period only. We have no concrete foundations.

CRESTON, IOWA. T. S. DELAY. POPULATION 6,924.

Repairs are unsatisfactory and need intelligent supervision. The soil is clay. There is no power ramming and 90% of the material removed is returned. There is no careful supervision by the city, workmen are not specially trained and are not under city pay.

Repaired pavement is brought about to the original surface. "Repairing is usually done by plumbers the first time, then street commissioner takes a shot at it with no better results, after which the chuck hole remains without further attention."

FRANFORT, INDIANA. R. H. BOYNTON. POPULATION 3,834.

Soil is clay with about one foot of loam on top. Water tamping formerly used but now discarded and hand tamping used. 85% to 90% of material put back. Old material from trenches is the only material used in back-filling, but we are considering the use of gravel for water-works trenches. A new ordinance has been passed—a copy of which is enclosed—and better repair work is now hoped for. The joints are cement filled and the blocks are mounded, but as we lay a 6-in. concrete slab, the edges of which are on the undisturbed earth, I believe the mounding will be better omitted and am experimenting with this at present. We have 4.83 miles of brick on sand foundation with cement grout filler and 1.52 miles of brick on sand with asphalt filler. In repaving we seldom use any of the old concrete base. I lay bricks directly in the fresh concrete and fill the joints with cement grout. The repairs are blocked from traffic for ten days or more.

In winter the earth is tamped into place to within one foot of the surface; the rest of the trench is filled with cinders, which are carefully tamped and dressed to fit the pavement surface. This cinder patch is retained until favorable weather for repaving.

LONGVIEW, TEXAS. H. N. ROBERTS. POPULATION, 5,155.

The soil is clay and sand and water-flushing is permitted. A concrete slab is used over trenches. It is thought that all repairs should be made by the city, and in future this will be done and a charge be made to the company or others opening the street. Repairs are brought to the same level as adjoining pavement and the reinforced concrete slab does not allow any settlement. In reinforcing we use $\frac{1}{2}$ -in. bars 6-in. between centers both ways, and five days are allowed for the concrete to set.

SEWICKLEY, PENNA. E. E. DUFF. POPULATION 4,479.

The street repair work has not been satisfactory during the past, as no great degree of attention has been given to the work and every contractor or plumber has been allowed to relay the surface according to his own ideas with the consequence that holes have developed and considerable repatching has to be done at the boro's expense. We will not consider that repairs are satisfactorily made till they are all made by the municipality and to further this idea we have recently revised our permit forms, giving the contractors the option of allowing the boro to make the repairs at the contractor's expense, or else compelling the contractor to repair under a comparatively strict specification. We have a sandy soil in practically all cases, flooding is satisfactory and a 10-ton steam roller is used to compact the fill thoroly after the same has been brought about 4 to 6-in. above the street level. Work that has been repaired and in service about a year

has not developed any holes. 95% to 100% of material removed is returned and occasionally we have to borrow dirt to complete the filling. The use of large quantities of water is advocated and no serious trouble has been met with from any settlement. Relaying of bricks is done by municipal men who are trained for that purpose, and it is advocated that all repairs be done by the municipality. We have not used any reinforcing in the concrete foundation in repair work, but have used a T-shaped section of plain concrete extending approximately 6-in. into the excavation, below the concrete foundation of the street, and 6-in. beyond the side walls of the excavation on each side. This concrete acts as a protection to the side walls and is heavy enough to carry the main load to the solid sub-base on the sides of the excavation. This concrete is made of 1 cement, 2 sand and 5 broken stone, gravel or crushed slag. No old concrete is relaid, 24 to 48 hours only allowed for concrete to set. We insist on 24 hours of effectual blocking, and while this is hardly long enough in some cases, we do not feel justified in blocking traffic for a longer period. A copy of permit to open the street is sent with attached coupons, etc. This permit allows the applicant the option of allowing the boro to make the repairs and agrees to pay for the same at cost plus 10%, which, of course, will relieve him of all responsibility. If the boro does the work a bill of materials is kept and contractor charged as shown on the back of the permit.

ROSELLE PARK, NEW JERSEY. W. H. LUSTER.

About 90% of the material removed is returned in back-filling. All repairs are made by the boro. We have no block pavement whatever.

GRANITE PAVEMENTS IN THE BORO OF MANHATTAN, NEW YORK CITY.

*By R. A. MacGregor, Assistant Engineer, Bureau of Highways,
Manhattan, New York City.*

Stone paving in New York city has been subject to a very gradual development since 1870, with quite a rapid advance beginning about 1910.

There are still in use in the Boro of Manhattan at least six varieties of stone pavement which have been standard for some length of time.

The oldest style, still in use, is the large square granite block, the head ranging from 6 by 6 inches to 8 by 8 inches or even 9 by 9 inches. Transverse Road No. 1, across Central Park from Sixty-fifth street and Fifth avenue to Sixty-sixth street and Central Park West, is the only existing pavement of this type in Manhattan that the writer knows of. It was laid in 1871 and 1872. Plate I.

This pavement was known as Belgian block. Belgian blocks of trap, about 4 to 5 inches square on top, followed, and of this there is still a considerable area in use. Plate II.

The oblong trap block, 6 to 12 inches long, 3 to 4 inches wide and 7 to 8 inches deep, was the next style and was considered a great improvement. A small amount of a similar shaped block, but a little smaller, made of Hudson River bluestone, was also laid and is still in use on a few streets. Plate III.

The last three varieties seem to have been the principal kinds laid between 1870 and 1890. After 1890 the standard stone block paving was what is now called old style granite block, 8 to 12 inches long, $3\frac{1}{2}$ to $4\frac{1}{2}$ inches wide and 7 to 8 inches deep, and it continued the standard for twenty years, till about 1910. Plate IV.

Our records show the oldest Belgian block (trap) still in use, to have been laid in 1870 on Avenue C, Fourteenth street to Eighteenth street; the oldest Belgian, granite, on Transverse Road No. 1, laid in 1871 and 1872, and the oldest oblong granite, on Twelfth



I. Large square granite Belgian blocks on Traverse Road No. 1 as laid in 1871 and 1872.

avenue from Thirty-fifth street to Thirty-seventh street, laid in 1872. These are yet in use, and some others may be older as the records are not complete prior to 1870. Belgian block of trap was laid as late as 1894 and oblong trap as late as 1893.

The total area of stone block pavements in Manhattan at December 31, 1915, was:

Belgian, trap, bluestone, etc.....	224,929 sq. yds.
Old style granite (oblong).....	1,580,663 sq. yds.
Improved granite (present style).....	735,347 sq. yds.

Total 2,540,939 sq. yds.

Of this area 96,000 sq. yds. were laid before 1880.

Our record, or blue book, shows the date of completion, contractor's name, price, area, etc., of all pavements laid since 1880 and of many between 1870 and 1880.

In addition to these varieties already mentioned there are small areas of medina stone, both large oblong and small square sizes, and a small piece of Durax.



II. Small trap Belgian blocks laid on 12th Avenue between 133d St. and 134th St., in form used between 1870 and 1890.

According to Mr. Tillson in his "Street Pavements and Paving Materials," a concrete base was first used regularly in 1888 and the first use of tar and gravel joints was by the Dock Department in 1881.

Practically all streets with concrete base had tar and gravel joints and since 1890 few streets in Manhattan have been paved with granite without a concrete base.

The writer will now try to follow the development of the granite block pavement in Manhattan up to its present state of perfection.

The tar filler for many years was a mixture of one hundred parts tar, twenty parts asphalt and three parts residuum oil. This asphalt was almost always Trinidad, partly because it was much easier to determine by analysis the proportion of asphalt used, owing to the inorganic matter present in Trinidad asphalt and absent from Bermudez asphalt.

The joints between the blocks were required not to exceed $\frac{3}{4}$ inch. The roughness of the old style block and the permitted variation in depth required a thick sand bed, and the deeper the sand

bed the better pleased were the pavers. It was so much more pleasant to drive the paving hammer into 3 or 4 inches of sand than to strike the concrete about 1 inch down. This deep bed allowed the block to settle under traffic as the ramming could not get every block down to a solid bearing. The rammers, or rammers-men as they were called, rammed the blocks till a comparatively even surface was obtained, but this did not prove that all were equally bedded. Traffic soon proved they were not, and water entering the joints and washing away the sand bed helped to make an uneven surface in a year or two. The wide joints also permitted the chipping of the corners, causing the blocks to become turtle backed as the adjacent stones gave no support to each other at the top.

On the whole it seems strange that practically no improvement was made in granite blocks between 1870 and 1910 in the pavement, tho the concrete base and tar filler were, of course, improvements.

The first improved granite laid in Manhattan was on Walker street between Lafayette street and West Broadway and completed in 1910. The specifications for the blocks were as follows:

The blocks to be used shall be of a durable, sound and uniform quality of granite, each stone measuring not less than 7 inches, nor



III. Oblong trap blocks of the third style described, laid on Transverse Road No. 2 in 1884, in form used between 1870 and 1890.

more than 11 inches in length, nor less than $3\frac{1}{2}$ nor more than $4\frac{1}{2}$ inches in width and 6 inches in depth. A variation of $\frac{1}{4}$ inch each way will be allowed in the depth of the blocks. * * * The blocks are to be rectangular on top and sides, uniform in thickness, to lay closely and with fair and true surfaces, free from bunches and so cut or dressed that they can be laid with joints not to exceed $\frac{3}{8}$ inch wide and approximately uniform. * * * The blocks must be separated before they are brought on the work into two classes, one from $3\frac{1}{2}$ to 4 inches and the other 4 to $4\frac{1}{2}$ inches and so delivered on the street.

Under the head of "Laying," joints were required not to "exceed $\frac{1}{2}$ inch in width and be practically uniform," and the writer thinks this clause allowing $\frac{1}{2}$ -inch joints was the one observed in construction. A mixture of tar and asphalt and $\frac{3}{8}$ -inch washed gravel was used as a joint filler. One-and-a-half-inch sand bed was required as a minimum.

Tho in 1911 the old style granite was still contracted for, and laid, a considerable amount of improved style granite was laid. The specifications were substantially those already given of work in 1910, except that the blocks were only $4\frac{3}{4}$ to $5\frac{1}{4}$ inches in depth. The joints were not to exceed $\frac{3}{8}$ inch and to be practically uniform. Hot dry gravel passing a $\frac{3}{8}$ -inch mesh was used in the joints with a tar and asphalt filler, and a 1-inch sand bed was specified. That year's specification, it will be seen, is still the standard for Manhattan as to size and has become practically the standard thruout the eastern states. The dressing, however, is finer than in most cities, a $\frac{1}{2}$ -inch joint being called for in the other boros and elsewhere.

In 1912 two grades were in use, viz: granite pavement and special granite pavement. The specifications for the first were as given for 1911 but with joints not to exceed $\frac{1}{2}$ inch. The contractor had the option of using a tar and asphalt mixture or a straight asphalt as filler, but very little of the latter was used.

The specifications for the special granite, or as it was called in a few contracts early in the year, special improved granite, were slightly more rigid as to dressing and as to the surface of the concrete base. The requirements were:

The blocks shall be rectangular with the tops and sides uniform in thickness, to lay closely and with a fair and true surface, free



IV. A good example of the old-style granite pavement which has had only enough traffic to wear off most of the tar from the surface, in form used between 1890 and 1910.

from bunches and so cut or dressed that when laid stone to stone the joints shall not exceed $\frac{3}{8}$ inch in width. The head of the block shall be so cut that it will not have more than $\frac{1}{4}$ inch depression from a straight edge laid in any direction across the head and held parallel to the general surface of the block. * * * The contractor shall select a definite width for the blocks to be used on this contract and notify the engineer of such selection. All blocks used on this contract shall be of the selected width with an allowable variation of $\frac{1}{4}$ inch each way from this width. The width selected with the allowable variation, must be within the general limitations for width of blocks specified above. * * * The top of the concrete shall be brought to a grade, by screeding or other satisfactory method, which shall not vary more than $\frac{1}{4}$ inch at any point from a surface parallel to and 6 inches below the finished surface of pavement. On this concrete shall be laid a bed of sand not to exceed 1 inch in thickness. * * * After the blocks are laid, dry sand shall be poured into the joints in such quantity as to fill same to within 3 inches of the top. The filler might be either the tar and asphalt mixture or straight asphalt.

The object in getting the concrete surface to such close conformity with the required pavement surface was to give the pavers a guide in laying the blocks, and as the blocks only varied $\frac{1}{4}$ inch

from the standard it proved a great help. Measurements were taken all over the work to test the distance the concrete was below the finished surface and, if necessary, the pavement was taken up and surplus sand removed. With the exceedingly close joints it was almost impossible to remove sand from any joints filled too full and almost as impossible to prevent laborers and rammers from brooming the sand into the joints until they were full.

In 1913 the specifications were identical with those of 1912 as already quoted. Experiments were made by the writer with the method of mixing hot sand and bituminous filler before pouring. The idea was not original with him, the method having been used in Britain, but he believes this was the first use of the method in this country, and it is gratifying to note that it is now considered the best practice and is adopted by progressive engineers in many places.

One Hundred and Twenty-ninth street, between Convent and Amsterdam avenues, was the first street on which this mixture was specified.

In 1914 the description of the quality of granite was a little more explicit. Heretofore it was required that the granite should be of a durable, sound and uniform quality. In 1914 and since, the specification required that "the granite from which the blocks are cut shall be medium grained, showing uniform in quality and texture, without seams, scales or discolorations showing disintegration, an even distribution of constituent minerals and free from an excess of mica, or feldspar. No outcrop, soft, brittle or seamy stone will be accepted."

This specification did not rule out the product of any locality previously supplying the city, tho it did to a great extent eliminate stones with one face discolored by seepage in the quarry seams. These faces were not weathered in any degree and tests with the hammer showed the granite as tough on the discolored face as elsewhere, but they were unsightly and to an inexperienced person would appear weathered or soft.

In 1913 and 1914 series of tests of various granites were made, duplicate samples being sent to Columbia University and the office of Public Roads. The results were published in the reports of the



V. Tamping template used to bring concrete base to grade.

Boro President of Manhattan for 1913 and 1914, but neither the series nor the results seemed to justify the specifying of any standard of hardness, toughness or compressive strength.

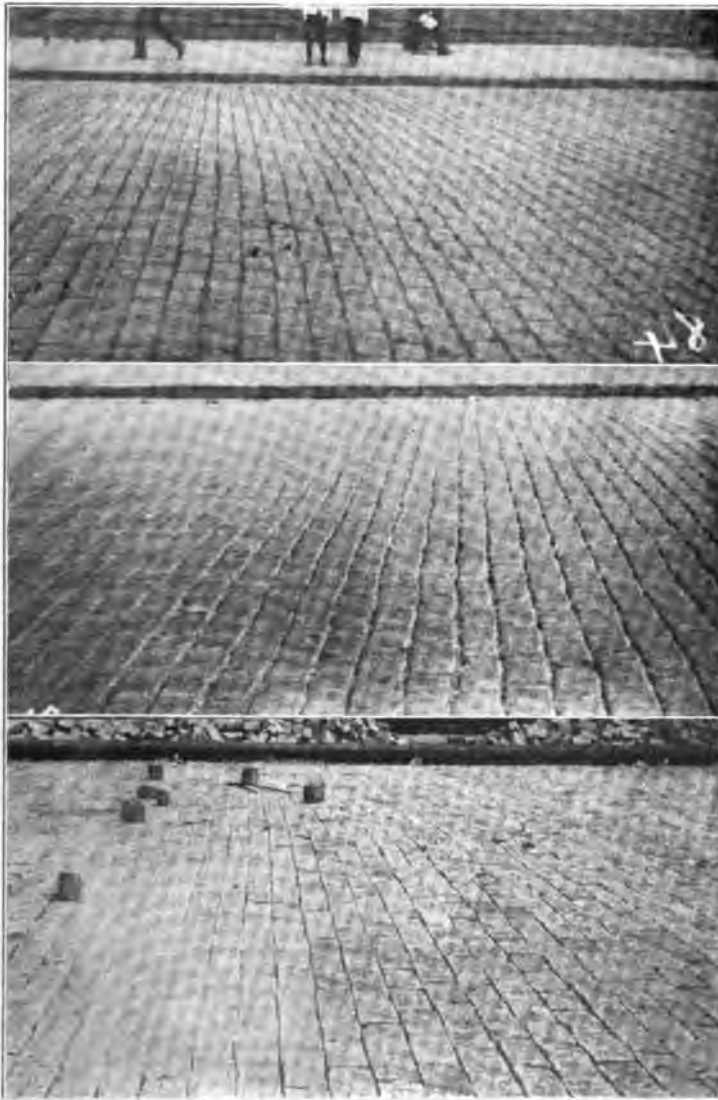
A new requirement was an inspection at the quarry or dock of 1,000 blocks to show not over 15 per cent. failing to comply with the specifications. This has been a great help in obtaining work on the street in closer conformity to the specifications. As it is, the 15 per cent. must be left to the watchfulness of the inspector, and undoubtedly some are passed if they can be laid close enough to the next block; this, of course, is quite possible if the rejection should have been made for depth.

It is our practice to have one of the supervising inspectors examine 500 or 1,000 blocks unloaded on the dock; he has each block picked up and if not plainly within the requirements as to dimensions or smoothness of face, measures it and if not acceptable orders it put aside. This is quite a rigid test and a good many cargoes in the last three years have been rejected and the blocks not up to requirements cut over. The cutters at the quarries are now sufficiently trained to give the desired dressing, but at first a great deal of culling was needed.

As much training had to be done with the pavers, who had all been accustomed to the old style granite with $\frac{3}{4}$ to 1-inch joints and 2 to 3 inches of sand. The new blocks are much easier to handle and set, but much more care is needed in matching the width and shape of adjoining stones. New York pavers nearly all use a heavy paving hammer and stand squarely in front of their work. British pavers, and some men trained in other cities, use a lighter hook hammer, standing with the side to the work, in this way keeping a much better line on the course, as well as doing the work of lifting and bedding more easily for themselves. These men were our mainstay at first in getting satisfactory work, but now most of our New York pavers do nearly as good work tho the writer thinks with greater effort, due to their method. Plate X shows this difference in method of work.

The filling of the joints with a mixture of sand and bitumen was incorporated in the 1914 specifications as the standard practice. It was soon found that a fine sand gave much better results, a coarse sand settling in the pouring can before it could be poured into the joints. The sand was and is heated and dried on the common open plate driers, usually made of an iron plate supported on some paving blocks with a wood fire underneath. It is added gradually to a half full can of filler and stirred thoroly. The amount permitted is equal volumes of sand and bituminous filler but this is rarely reached and about 1 part sand to 2 or 3 of filler is the usual proportion. The thick portion of the mixture is dumped out of the can into the wider joints, but a good deal of it remains on the surface.

In 1914 another new requirement was that no sand be allowed to be put into the joints except when mixed with filler and no pinch bars were allowed except by special permission of the engineer, tongs being used to remove any blocks. The writer must confess his skepticism as to the practicability of paving without sand or grit to key the blocks while being rammed, but tests showed it to be possible and now tho the specification allows a little sand to be used, he does not permit it at all. The blocks are laid so close together that there is little rocking and, if no walking on them is allowed except by the rammers and joint fillers, the blocks remain in place. The prohibition of pinch bars was put in force as it was found that the raising of low blocks by the old method of rooting



VI. New granite block pavement in Lafayette St., photographed in 1913 when one year old.

VII. Lafayette St. at same place in 1916 when four years old.

VIII. Ninety-sixth St. between 2d Ave. and 3d ave., just laid, in 1914. See also Plate IX.

and pinching destroyed the regularity of the courses and that the paving looked and was 100 per cent. worse for the attentions of the rammers. Now they carefully tap each block with the heavy paving rammer, the shallow sand bed preventing any great unevenness of sinkage; then with the tongs they remove any high, low or defective blocks, with the hand take out or add a little sand and put the block in place. The old specifications and union rules call for one rammer to two pavers, but such a proportion is not needed on this class of work and one to three is sufficient. The writer's method is to have the rammers, after the first ramming, use their tongs to remove blocks condemned by the inspector, then, with a shovelful of dry sand placed conveniently, take out high and low blocks, make the bed the proper height, put them back or substitute acceptable blocks for those condemned, then give the whole surface the second ramming.

The use of a dry mortar bed composed of 1 part portland cement and 3 parts sand was also made the standard this year. The sand has usually enough moisture in it to set the cement within 24 hours without adding any water to it. Enough mortar is usually mixed to last the pavers about 2 hours and it is spread on the concrete base just as sand would be. This mixture has been in use for years under asphalt blocks and to a considerable extent under wood blocks and is now the standard bed for all kinds of block paving in Manhattan. As this mortar sets it prevents the washing away of the bed from beneath the stones when water is able to penetrate to the base, as will happen with the most careful inspection.

The method of pouring the joints without any sand or gravel being previously put in them tends to make the pavement more nearly waterproof, as the joints are filled with the fluid mixture and no spaces are filled with dry sand only covered with a skin of filler.

Due to the injury to the bituminous filler by overheating, thermometers were required in each heating kettle and maximum and minimum limits of temperature were specified for each kind of filler. That this control was needed was proved by a comparison of the samples taken each day from the kettles on the street and the sample from the barrel or from the tank at the manufactory. These thermometers have usually a stem about 4 feet long so as to show above the edge of the kettle over which they hook.



IX. Ninety-sixth St. at same place as Plate VIII, photographed in 1916.

X. First Ave. and 113th St., laid in 1913, showing method of laying blocks with hook hammers.

XI. First Ave. and 113th St., photographed in 1916.

The 1915 and 1916 specifications are essentially the same as those of 1914 as regards the blocks. The concrete base is required to be struck off with a template conforming to the crown of the street. This is done by the use of a heavy plank usually 9 by 3½ inches, as long as the roadway is wide and cut to the shape of the crown. It is equipped with a handle at each end, two men lifting and dropping this, so tamping the concrete as well as bringing it to the required shape and contour. In addition, stakes are driven at three or more points on the cross section and not more than 8 or 10 feet apart longitudinally, to which grade stakes the rakers place the concrete. This tamping bar was seen by the writer in use by a contractor near Swampscott, Massachusetts, and he hereby makes acknowledgment of his indebtedness to this unknown contractor. See plate V.

A better grading of the concrete materials and longer mixing in batch mixers exclusively were new features of the 1915 and 1916 specifications, rotary batch mixers having first been required in 1914.

Up to the year 1914 very little detail was given in the specifications regarding the bituminous filler. The coal tar was "such as is ordinarily number 4 at the manufactory," and for a good many years, up to 1914, the mixture of tar and asphalt was specified, this mixture being made to overcome the brittleness of the tar at low temperatures. It would seem that the character of the tar has been gradually changing as might be expected from the changes in the process of manufacture. In 1914 an attempt was made to get a straight run tar which would not be too soft in summer nor too hard in winter. Various requirements, such as melting point, free carbon, specific gravity, etc., were given after many experiments and tests. This filler did not come up to expectations, however. In 1915 practically all, and in 1916 all the work done had asphaltic filler mixed with sand, as was done in 1914.

Mr. Stern, Chief Engineer of Highways, states that his decision to require asphaltic filler instead of tar filler was based on observation and comparison of both fillers used in 1915.

The asphaltic filler is certainly less brittle than the tar filler but does not seem to be as adhesive, especially when the blocks are cold and damp, and it is also more difficult to melt. So far the manufac-



XII. First Ave. and 118th St., photographed in 1913, just completed.

XIII. First Ave. and 118th St., same year, photographed in 1916.

XIV. Jackson St., near the East river, as laid in 1913. See also Plate XV.

turers have not delivered it hot in 400 or 500-gallon tanks as was done with tar filler. This method was a great time and fuel saver as the liquid material was pumped by air pressure into the contractor's melting kettle and only required to be kept hot. A few barrels of the material could be on hand for emergencies, and it is to be hoped that asphalt manufacturers will adopt this plan soon.

Careful records of materials delivered on a number of contracts show that about $2\frac{1}{4}$ to $2\frac{1}{2}$ gallons of filler are used per square yard of present style paving. A considerable saving of filler can be made by the use of a larger proportion of sand, the bulk of the mixture being, of course, increased by the absolute volume of the sand, that is, its volume minus the voids. A sand with 40 per cent. of voids would add at least 60 per cent. of its bulk to the volume of the mixture and at the relative prices of sand and bituminous filler, a substantial saving is made even after allowing for extra cost of heating and mixing the sand. In Brooklyn and some other cities the mixture of filler and sand is dumped on the surface of the pavement and pushed into the joints with squeegees. From reports it seems to be very successful, as a larger proportion of sand, as high as equal volumes of sand and filler, can be used, and probably very little more filler is left on the surface than by the pouring method. The writer has not tried this method over more than a few yards, but was very favorably impressed with the result and speed. A sand with a grading equal to an average asphalt sand should be used.

Bids have been asked for paving one of the Transverse roads across Central Park with granite with portland cement joints, and it is the intention to pave two other Transverse roads with the same kind of pavement. The amount of cutting for subsurface work on these roads will be negligible, and they, therefore, seem to be ideal for the use of cement grout as a filler. Only one or two blocks in Manhattan had cement grout joints laid in recent years. It is practically impossible to close Manhattan streets absolutely to vehicular traffic for seven to ten days or to protect patches for a similar length of time; for this reason bituminous filler is the standard in Manhattan. In this connection it is interesting to note that the area of cuts made in Manhattan in 1915 was equal to a 16-foot roadway 15 miles long.

Now as to the results we are getting under these rigid require-



XV. Jackson St., same place as Plate XIV. Photographed in 1916. This street has a very heavy iron-tired traffic to the docks.

ments. A count of joints between 8 pairs of courses chosen at random across a 42-foot roadway showed only 19 spaces wide enough to admit a $\frac{1}{2}$ -inch rule. With 63 stones to a course this is less than 4 per cent. of the joints and most of these spaces were less than 3 inches long or about the lap of the adjacent stones. On another street a similar count of 10 pairs of courses, 30 stones to a course, showed only 10 spaces $\frac{1}{2}$ -inch wide, none over 3 inches long, and more than 50 per cent. of the joints would not admit a rule $\frac{1}{8}$ inch thick. This equals about 3 1-3 per cent. over $\frac{3}{8}$ -inch joint. Another street was tested with a 6-foot straight edge parallel to the curb and showed only two or three places with as much as $\frac{1}{2}$ inch depression, all other places being $\frac{3}{8}$ inch or less.

The plates accompanying this paper show some streets before the filler was poured, with the work as finished by the rammer, and the same piece of work two or three years later. All show some spalling at the joints, but not much considering the intense traffic most of them carry.

It is to be noted that the plates show fair samples of the work, not by any means exhibition places.

THE RE-PAVING OF BROAD STREET, ELIZABETH, N. J., WITH GROUTED GRANITE BLOCK.

By Thomas E. Collins, City Engineer.

In the following description and explanation of the work of repaving the main business street, Broad street, of Elizabeth, N. J., the subject is presented from a complete angle rather than as a specific and bare statement of the details.

The facts and statements which follow are not theoretical, in any sense, and the results obtained are self-evident. Fortunately, in this case, the city of Elizabeth is but a short twenty-five minutes' trolley ride from this city of Newark, and you can see what we have accomplished.

What is more interesting and convincing still, is the possibility of noting all along the line of the trolley, if you take a Frelinghuysen Avenue car, a series of jobs of grouted granite block paving, sections of which are the equal of what we have done.

The present attitude of the citizens of Elizabeth, which is probably the attitude of the citizens of a majority of our cities and towns, makes it good policy to start with the citizen as the initial feature in any paving job.

Before Broad street was repaved with cement grouted improved granite block, it was covered with the old trap-rock Belgian block 6 and 8 inches square, laid on sand foundations with wide sand joints, upheaved by every freeze and thaw, rutted and pot-holed by traffic, and so annoying to the ear of the business man and pedestrian, that no one who used or viewed the pavement on the street would ever say a kind word for the engineering and highway department.

Our problem was not only the one of making a proper selection of material and of determining on a satisfactory plan to finance the project, but the citizen must also be directly satisfied and pleased.

The average citizen does not seem to be aware that he is needed



Broad St., Elizabeth, N. J. Old Belgian Block Street, 1915, before Granite Block was laid.

and is a partner in any effort to remake the pavements of Elizabeth into modern, smooth, sanitary and up-to-date types.

After we, in the engineering department, and the board of public works, had made a definite decision that Broad street needed first attention, and after approval of our decision by Mayor Mravlag, a regular visitation plan was carried out among leading property owners of Broad street along the line where the pavement was to be laid, and an expression was secured as to their willingness to pay their proper proportion of the cost and their approval of the plan to bond the city for the difference. Large taxpayers were also consulted by individual city officials, until finally we were all confident a direct move toward the paving of Broad street would meet with the favor of the majority, not only from the standpoint of need, but with their belief that the plan of raising funds and their share of the payment by assesment and bond issue, was the correct procedure.

At this point it may be well to comment on the abominable practice which has sprung up in so many cities of manufacturers and their representatives carrying out petition-solicitation without regard to the merits of their pavements for the particular street along which they circulate their petition. These petitions are usually solicited without consultation with the engineer and in many



Broad St., Ellizabeth, N. J. The correct way to unload Paving Blocks.

cases erroneous statements are made which later tend to seriously reflect on the standing and integrity of the engineer.

It seems to me the American Society of Municipal Improvements might well take a stand on this subject at this meeting, not only to condemn this practice, but pledge itself to use all influence possible with city officials, material men, contractors and manufacturers, to stop house-to-house petition work, until after the engineer has been consulted and has approved their material for the street work. This would not mean that only one material would be solicited. In most cases there are several competing materials which will serve as good pavements for particular streets; but it is a fact, that many times recently, cases have been noted where, by petition work, a wrong selection of pavement was made and within 2 to 3 years the engineer in charge was being blamed and discredited because the material failed to stand up to the statements made by the manufacturer's representative when used under the conditions on that particular street.

Therefore, having taken the citizens into conference on the question of cost and the initiation of means for securing the needed money, the next step for the board of public works, and the engineering department, co-operating with the Mayor, was the thorough investigation of the various types of pavements in use and the selec-

tion of that type which would please and serve the greatest number of citizens and conserve the respect which the board of public works and engineer knew would be theirs if they purchased wisely from the standpoint of both economy and ultimate life and freedom from repairs.

To insure an unbiased selection based on value to be received, a series of meetings and conferences, both public and semi-public, were held by the Mayor and board of public works, and all the different paving material manufacturers and contractors were given a full and unprejudiced hearing. These hearings were not of the type of the old days, packed hearings or held behind closed doors and with the predetermined plan to be carried out, but they frequently extended into the late hours of the night and covered a field of research and discussion which was often severe in the extreme but broadly instructive to the citizen and layman.

Following the hearings and meetings in Elizabeth, the Mayor, the board, the engineer and some citizens, made investigation and inspection tours into Newark, New York City, Brooklyn, Jersey points in general, to manufacturing plants where materials were made and to the stone quarries and New England cities having all or many forms of pavements.

Tabulations and layouts were then made, covering the different types of materials, costs, approximated life, maintenance costs, needs of vehicle owners, volume of traffic, etc. and all points were carefully considered.

The result of these investigations showed us that there is no one solution to the paving problem. Practically every type of pavement being laid anywhere today has its proper place, and in that place will prove most economical and usually most serviceable.

I will give some of the reasons why the Mayor, the board of public works, and the engineer, all agreed that granite was the best pavement for us to lay on Broad street.

In the first place Broad street is a wide street running thru the business section of Elizabeth and acting as a connecting highway between Newark and Trenton.

It is flanked on both sides by low business buildings and there are



Broad St., Elizabeth, N. J. Showing Even Courses and Smooth Heads of Granite Blocks.

no shade trees on the street in the business section, thus it is all exposed to the intense rays of the summer sun and to all the rigors of freezing and thawing in winter; making it imperative that a pavement be selected which would be as free as possible from the influence of the elements, such as expansion, contraction, moisture, softening or hardening, etc.

Double street car tracks run thru the entire length of the street and over these are run heavy interurban cars between Newark and Trenton, making necessary a pavement which could not be affected by street car vibration.

Traffic at times is exceedingly heavy and at all times it consists of both heavy motor trucks and heavy horse-drawn vehicles, in addition to the standard pleasure vehicles; and both motor and horse-drawn trucks are frequently heavily loaded and run at a good speed on account of the width of the street increasing the speed safety factor. This called for a pavement which would not be slippery in wet weather and which would give good foothold for horses and good tire hold for fast auto trucks.

As the grade at the northerly end of Broad street is about 5 per cent, it was especially important for this reason also to secure a pavement which would afford a good foothold. The question of

frequent or infrequent repairs entered largely into our calculations as the repair department must necessarily be kept at a minimum.

As far as possible, all sewer, electric light and gas connections were made and other underground work was done before the pavement was laid, so the question of frequent openings did not have to be taken up, and this favored the laying of grouted granite block.

The pavement was to be paid for by the citizens in part thru direct bond assessment against the abutting property and the balance by a bond issue, and the difficulty of getting two or three such plans thru a city administration during the life of a citizen on the street, and of sometimes getting a second or even a third bond issue passed for payment before the first had been amortized, also had considerable weight in our calculations. Fortunately, or unfortunately, Elizabeth had had just such an experience in its past, having been almost bankrupted at one time thru the laying of the old style round cedar block pavements under bond issues, and many of its citizens bitterly remember that fact.

Our investigations in the different cities where grouted granite block pavements had been laid, either on business or residence streets, especially in Worcester, Mass., where this style of pavement was first laid about 20 years ago; and in Lawrence, Lowell, and Brookline, Mass.; and in New York City boros and right next door, here in Newark, proved conclusively that grouted granite pavements were still in existence intact after 20 years of service, and down to six or eight years right here at home, and without cost for repair or maintenance or blocking off of traffic for repairs at any time.

Reports received from the Society for the Prevention of Cruelty to Animals, the Automobile Clubs, the Motor Truck Club of New York, and the various Team Owners' Associations, all favored the modern improved granite block pavement from a safety standpoint and from the point of view of the vehicle owner who desired a pavement which would take care of all kinds of loads handled by any kind of vehicle and under all weather conditions.

All of these factors led us to conclude and the citizen to agree with us, that no mistake, at least, could be made if we spent the returns of the bond issue for granite on Broad street, and this was the pavement finally selected.



Broad St., Elizabeth, N. Y. Grout Mixer at work.

The writer gives these various points, not only to show how this particular decision was made in this case, but to point out more strongly than he could, otherwise, the need of the up-to-date engineer making a careful calculation and investigation in every case, and still more important the advantage of securing the aid of the modern business man and vehicle owner, in determining the proper materials to use. It is a fact that the development and rapid extension of the use of automobiles and motor vehicles has brought into existence a thousand students of paving and paving problems from the practical standpoint where engineers formerly had to deal with only occasional single kickers, who were poorly or not at all informed about the laying of a pavement or the demand made on it when in practical use.

Our next step in the resurfacing of Broad street, was entirely an engineering problem. Grouted granite blocks having been selected, and having the experience of Newark right at our door, where contractors had handled granite blocks and secured good results, such as that beautiful six (6) mile stretch on Bloomfield Avenue, between Newark and Montclair, it was necessary to decide what care

was needed and what specifications would give the good results which we knew had been secured on Main street, Worcester, Mass., 15 years before and on Bloomfield Avenue, some five years ago.

The illustrations which accompany this paper show almost as clearly as written description could cover it, all the detail of the work and how it was carried out, including one illustration showing the abominable condition of the old style Belgian block pavement which was replaced.

In starting the work on Broad street it was necessary to provide for a continuance of traffic on the street, and this was handled by paving only one side at a time.

In order to reduce the cost of the pavement to a minimum, one of the provisions of the specification required that the contractor should place a value on the old blocks in the street, and with this item deducted the city was enabled to secure the very low net figure of \$2.97 per square yard, which included removal of old blocks from the street, excavation of sub-grade to the depth of about eight inches, thoroly rolling the sub-grade, placing of a six-inch concrete base and sand cushion of one and one-fourth-inch depth and laying and grouting of the standard blocks.

The old blocks were removed by the contractor to a crushing plant about a quarter of a mile away from the job, and these blocks were crushed. The stone was used in the concrete just as it came from the crusher, excluding only dust and all stone over two inches in size, giving us a very dense, firm mixture. Our concrete specifications called for a mixture of 1-3-6 and for mixing in a standard machine mixer, each batch to remain in motion in the mixer for not less than one minute.

The sub-soil was found in good condition and well drained, and required no special tamping except where openings had been made. A ten-ton roller was used for thoro compacting.

Concrete foundation after being placed was allowed to set for seven (7) days before the blocks were laid on it. A thin coating of sand was thrown over it to protect it from the sun and this was sprinkled two and three times each day.

In laying the pavement great care was used to see that the blocks



Grouting Intersection on Broad St., Elizabeth, N. J.

in courses were of uniform width, that all heads of blocks were up properly, that joints were of regular width not exceeding one-half inch and all end joints broken three inches or more.

Block specifications required heads having no projections over three-eighths inch.

Only sufficient pea stone was allowed in the joints to properly pin the blocks, and all blocks were carefully rammed to a firm hard base, one rammerman being required to every three pavers. Extreme care was taken to see that all joints were fully open for a depth of not less than four inches down from the top, as previous experience has shown pot holes will never develop when blocks are properly grouted to this depth or more in the joint.

All blocks were brought to the job in motor trucks and placed on the concrete foundation as fast as the pavers could use them, thus freeing the street from obstruction and saving the rehandling of the blocks.

The grout mixture was one part sand to one part cement and this same mix was used for both the initial and second pouring.

All blocks were thoroly wet before grouting and the initial grout was also sprinkled just before the second coat was applied, in order to secure a thoro bond.

The part of the work done in 1915 was grouted by hand mixed grout, and we found it required constant attention to keep it in condition with sand and cement in proper suspension until it filled the joints.

The grouting done this year, 1916, was all machine work, and we found this method effected quite a saving in the item of labor cost, and in addition the result shows a better and more uniform quality of pavement.

After the second pouring, the work was gone over with a rubber squeegee to remove all surplus grout from the top of the blocks, care being taken to see that all joints remained full. This eliminates all annoyance from dust resulting from too much grout covering the surface of the pavement.

All traffic was kept off the pavement for a period of ten (10) days, and the surface was sprinkled regularly twice a day during this time. In the future it is planned to use sand to cover the pavement, as this will undoubtedly better protect the surface from the sun. In using sand, however, it must not be spread until after the grout gets its initial set or it will take out some of the grout from the joints.

Four-cut granite curb 6 by 18 inches, was set all along the line of the street where paving was done and granite header 5 by 16 inches was used at all intersections. The curb cost us \$1.05 per linear foot, set in concrete six inches on all sides and six inches down from the top at the back. The header stone cost \$0.80 per linear foot set in concrete.

Our contract calls for a guarantee period of three (3) years.

City inspectors were constantly on the job and the contractor was under the watchful eyes of numbers of citizens who had grown somewhat familiar with pavements thru their investigation work,



Completed Grouted Granite Block Pavement on Broad St., Elizabeth, N. J.

and it is a fact, in this case, that the contractor has delivered a better job to the city of Elizabeth than he had expected he could do.

As a result of the paving of Broad street, and the general satisfaction of the citizens of Elizabeth over the excellent pavement secured, contracts have been let for approximately \$130,000 worth of additional grouted granite block paving, all being on the basis that the abutting property owner pays one-half the cost.

SOME EXPERIENCES WITH CONCRETE PAVING.

By K. C. Gaynor, Sioux City, Iowa.

Some seven years ago the City Council of Sioux City, Iowa, desired to pave some residence streets, and as the cost was to be assessed to the abutting property, it became necessary to find some kind of pavement which could be put down for about \$1.25 per square yard, and I, as city engineer, was instructed to find some pavement which would answer the purpose at the above price. After looking over some pavement which had been put down some twelve years previously in LeMars, Iowa, and the concrete streets of Windsor, Ont., I reported to the council that I thought concrete would answer the purpose, and they decided to pave some four miles of city streets with concrete.

I will mention only the essential features of this pavement and its condition at the present time.

The sub-grade was finished as for any pavement.

The streets paved varied in width from 24 to 52 feet. The concrete was mixed 1:3:4½ and the pavement was laid 5 inches thick. The sand was a fairly clean bank sand, and the stone came from the Sioux Falls, S. D., district, being a hard jasper.

The concrete was mixed fairly wet, and was first floated with a long-handled wood float. Then a mixture of half sand and half cement was sprinkled on it in sufficient amount to take up the surplus water, and to cover any stones which might have been uncovered by the first floating, and was then floated again. No templet or screed was used, the grade being obtained by eye.

One-inch expansion joints were placed across the street every 25 feet and along the curbs, and contraction joints, which were just cuts, were placed in between the expansion joints and also parallel with the street, this leaving the concrete in blocks about 12 feet square. After the first half mile of pavement was laid, the contraction joints were omitted owing to the difficulty of making them, and only the expansion joints retained.

One-inch boards were used in the expansion joints, and after the concrete had set, the boards were removed and the joints filled with bitumen. The edges of the joints were carefully tooled, and considerable effort expended in order to get the surface of the concrete at both sides of the joint at the same elevation.

The concrete was laid on grades up to 16 per cent. On grades over 7 per cent. the surface was corrugated by marking the concrete every 5 inches.

As the time has passed, the main points of construction have been continued, except that the specifications have been changed so as to require a richer mix, and the thickness has been increased to 6 inches, and in some places more, depending on the street, and, elastite has been used in the joints on account of the greater ease in construction.

These streets now, after five years' use, are still in good condition, and do not show enough wear to make it possible to estimate their probable life.

Very few cracks have developed, and inasmuch as the few cracks that have developed and the expansion joints have been taken care of by filling with tar and sand about twice a year, the cracks have not been objectionable, except as for looks. Neither the joints nor the cracks have ravelled out.

About 65 miles of streets and roads have been built in Sioux City up to date of this type of construction, and very little other pavement has been laid.

The maintenance of this concrete pavement has been practically nothing, the only cost being the filling of the joints as above mentioned.

Concrete paving is also laid between the car tracks, and the service company now uses it as a standard type of construction on all streets including those paved with asphalt.

The points of construction upon which the greatest emphasis has been laid, are clean, well-graded sand, hard stone, and much work and care taken with the finishing. This matter of finishing is very important, and too much stress cannot be laid upon it.

All this pavement has been laid in Sioux City without steel expansion joints, and no reinforcing has been used. In LeMars and Sheldon, the steel joints have been used, but I do not believe that the results obtained justify the additional cost.

DISCUSSION.

A MEMBER: May I ask the speaker as to these corrugations, which you speak of being about five inches apart. Is there any danger of their chipping? How deep were they laid?

MR. GAYNOR: They were not very deep, not over a quarter of an inch, but they were not necessary.

A MEMBER: On a 16 per cent. grade?

MR. GAYNOR: Yes, but they were not necessary. No team can get up a 6 per cent. grade with much of a load. It is a pretty steep hill. I have watched very carefully, gone along with teams just to watch the action of the horses' feet, and I found they did not slip as much as I thought they would.

A MEMBER: What mixture do you use?

MR. GAYNOR: We use 1:3:4.5.

A MEMBER: Does this not produce an excess of mortar?

MR. GAYNOR: It does not produce a very great excess of mortar, because the stone we used is a very hard stone which crushes up very uniformly and the voids are very high in this stone. And it has always been my practice to not have an excess of mortar if I can help it, not any more than just enough to fill up.

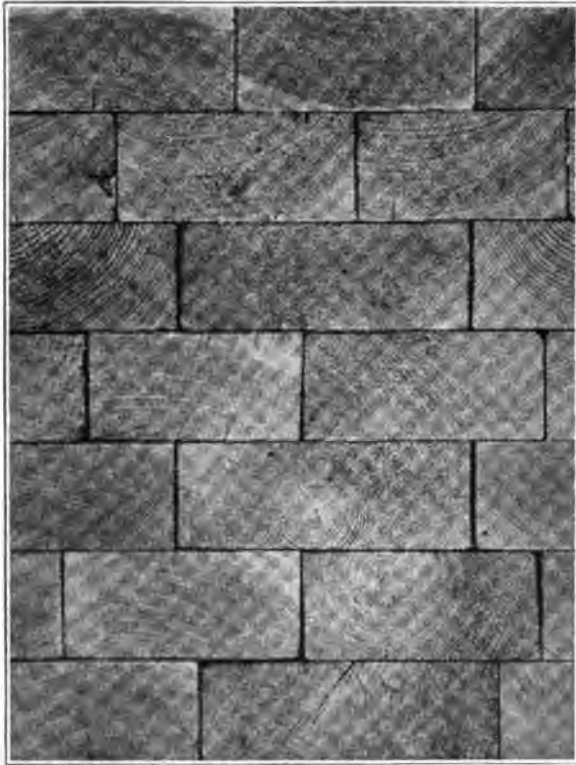
THE PROPER OIL FOR TREATING CREOSOTED WOOD BLOCKS FOR PAVING.

By P. C. Reilly, Indianapolis, Ind.

If a city engineer, or any official, in charge of paving were to be asked these questions: "In constructing pavements from a composite material in which the wearing surface (the wood) is of a character requiring protection against destruction by the natural elements, would you use for the protecting element a material not sufficiently stable to give to the wearing material the needed protection against chemical and physical destruction?" "Would you select the best material obtainable; provided a first-class, stable, high-grade material, suitable in every respect for the purpose of protecting wood fiber, could be obtained in sufficient quantity and at a reasonable price?" It is reasonable to suppose that the answer to the first question would be "no," and to the second question "yes." By this interrogatory introduction I mean to draw your attention to the present conditions of the creosoted wood block industry, for many creosoted wood block pavements are now being laid with blocks manufactured under a specification either permitting or requiring that an unstable and comparatively deficient protective material be used.

A pavement which, a few years ago, possessed a surplus volume of supporting strength over and above the heaviest traffic weight then required to be supported and which was, under such traffic, entirely successful and satisfactory, would not now be found sufficiently strong and durable to withstand the heavy thrusts made on it by the increase in weight of loads being carried on motor trucks. These weights will increase in the future. Manufactured wearing surfaces of every kind must now be constructed to possess their maximum resistance to wear, instead of being constructed on the basis of past successes under less severe usage.

A wood block pavement made from close fitting, untreated rectangular blocks, presents a wearing surface which, although unfinished in manufacture, produces a favorable impression when first laid and for a short time thereafter. (See Plate I.) It was not

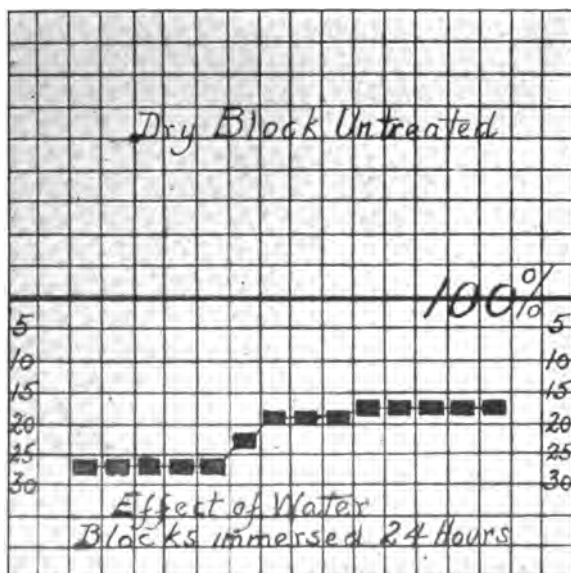


I. A pavement made of untreated wood blocks would be destroyed by the adverse natural elements. The blocks comprising the pavement would begin to weaken immediately after exposure and would continue to reduce in strength until totally destroyed; and this destruction would occur even if they received no traffic. The vital element, therefore, in a creosoted wood block pavement is the oil used for the purpose of preserving and protecting the blocks.

uncommon to find an untreated wood block pavement in fairly good shape for as much as five years. Improperly treated blocks produce the same favorable impression and under ordinary conditions, for a longer period than that of the untreated blocks. The favorable deductions from such superficial appearances of the untreated and imperfectly treated blocks have certainly been a drawback to the advancement of this pavement to the superior position it is destined to attain.

Another serious hindrance is and has been the widely published deductions from some experiments made with this type of pave-

ment which has been under observation only a short time, from one to five years, and in some cases less than one year. From these highly favorable deductions, founded on false conclusions, several harmful suggestions and specifications have been issued, and are still being advocated. One of the most recent specifications, sure to prove harmful to the wood block industry, but which, however, has no relation to the original impressive appearance of the blocks, is a specification now being put forth by some for the correction of bleeding. The blocks that bleed tar must, of course, first be treated with tar. The blocks are treated by the usual method of preliminary steaming and vacuum, and then treated with the preservative material under pressure. The specifications, presented for the purpose of removing the obnoxious bleeding, require after the oil has been injected into the blocks that they be subjected to steaming at a high temperature and to a vacuum of 20 inches to produce artificial bleeding; thus the bleeding on the street is minimized, but it is at the expense of the strength of the block. The first error was committed in using such a mixture, and the second one, a more serious one, in trying to correct the first.



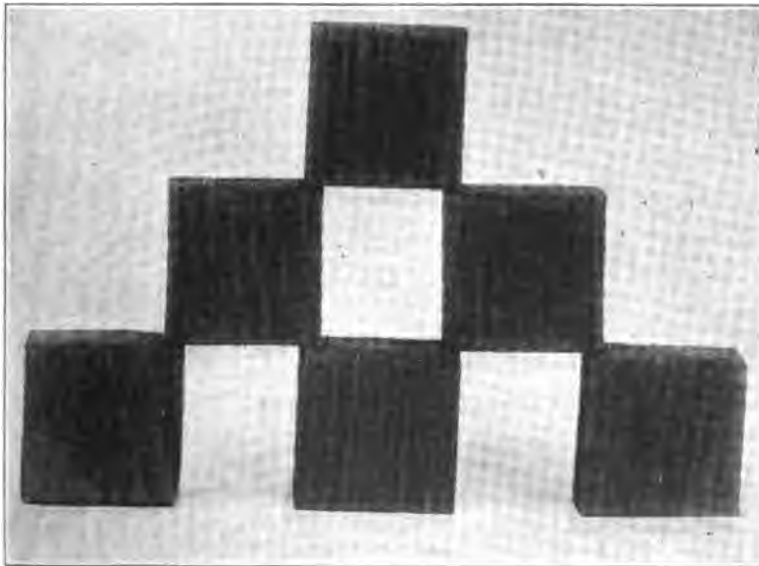
II. Diagram showing the effect of hydraulic pressure on untreated blocks after 24 hours' immersion in water, the loss in strength ranging between 17½ and 27½ per cent.

To illustrate the injurious effect on wood fiber by steaming, Plate II is shown. The line thru the center represents the strength (100 per cent.) of the long leaf yellow pine block. The decrease in strength is shown below the center line and is rated in percentages; the increase in strength is shown above the line, and, likewise, is shown in percentages. In this plate is shown the weakening effect upon the blocks after having been immersed in water for 24 hours. Twelve blocks were immersed for this period and after this short time exposure the blocks weakened $17\frac{1}{2}$ to $27\frac{1}{2}$ per cent., as shown in the diagram on Plate II. The test for determining the strength was made with a hydraulic pressure cylinder.

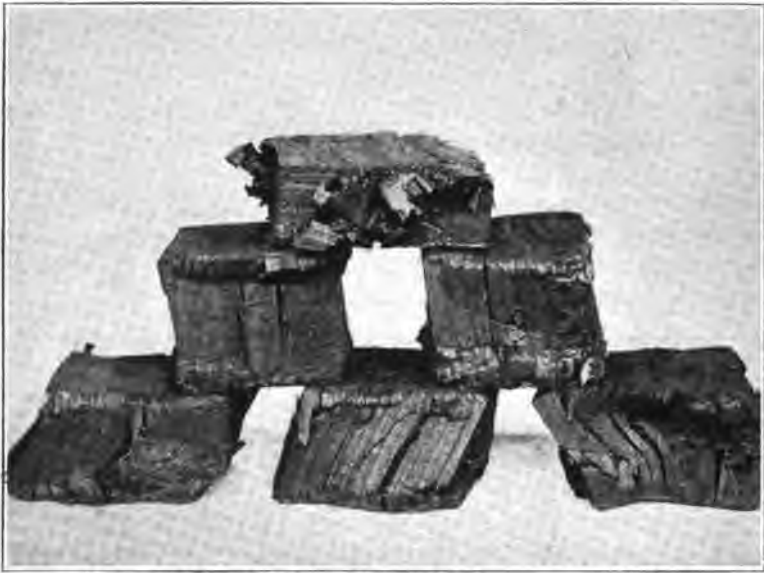
Plate III shows treated blocks (1-inch cubes) before being subjected to pressure.

Plate IV shows the same blocks, after immersion in water for 24 hours, and then subjected to pressure.

Plate V shows the same size blocks, treated as in Plate III, but not subjected to steaming in treatment. These blocks were much stronger than the blocks which were saturated with water by steam-



III. Treated blocks (1-inch cubes) before being subjected to pressure.



IV. The same treated blocks as shown in Plate III after being immersed in water for 24 hours and then subjected to pressure.

ing and it will be observed that, instead of pressing down and becoming shapeless under the pressure, they stood up under the pressure until a greater pressure caused a clean breakage of the fiber. These blocks broke at an average of 54 per cent. higher than that under which the blocks compressed as shown in Plate IV. There has not been a case, to my knowledge, where the traffic has been heavy enough to break a block.

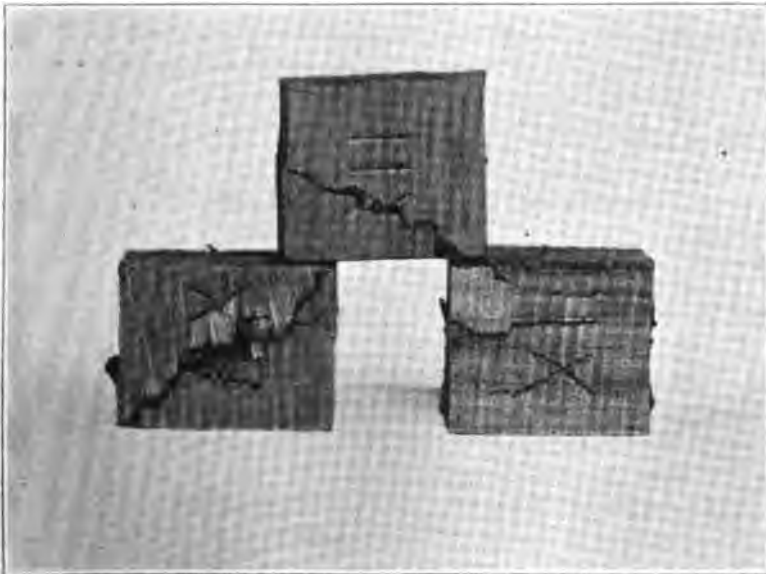
Steaming weakens the fiber of the block. It does more than that. It brings the fiber back, in a way, to its original absorptive condition, and it is known that the fiber in its original condition is not fit for paving. This treatment, therefore, not only has a destructive influence on the blocks at the time of treatment, but it prepares the way for them to be continually acted upon adversely by the elements; whereas, they require and should receive protection against the elements. In other words, it prepares the way for continuous destruction.

You probably have seen some blocks in street pavements, which, under stress, were mashed to splinters, and the blocks, instead of

being compact units, were a mass of slivers. This breaking up of the wood structure was undoubtedly due to the blocks in treatment having been subjected to excessive steaming, probably because it was necessary to obtain penetration.

In preparing the blocks to receive the oil, live steam should not be used in the process. With steam heated from 220 to 240 degrees F. the steam is forced into the blocks, and, as the interior of the blocks is cooler than the exterior—for wood is a poor conductor—the steam condenses and remains in the blocks. Blocks in their normal condition, when so steamed, never weigh less than their weight before being steamed, and they are generally increased in weight, the average increase being about 7 per cent., so that if blocks weigh 54 pounds to the cubic foot an increase in weight of 3 pounds per cubic foot may be expected because of this added moisture. This increase in moisture greatly decreases the strength of the blocks. This method, therefore, of preparing the blocks should never be used.

Wood blocks should be placed in a cylinder and covered with



V. Blocks of the same size and treatment as shown in Plate III, but not subjected to steaming before being put under pressure.

creosote oil at a temperature of 180 degrees F. The oil should be kept at this temperature and a vacuum of about 22 inches produced until all the moisture is extracted from the blocks. Then by a pressure pump force into the blocks the specified amount of oil.

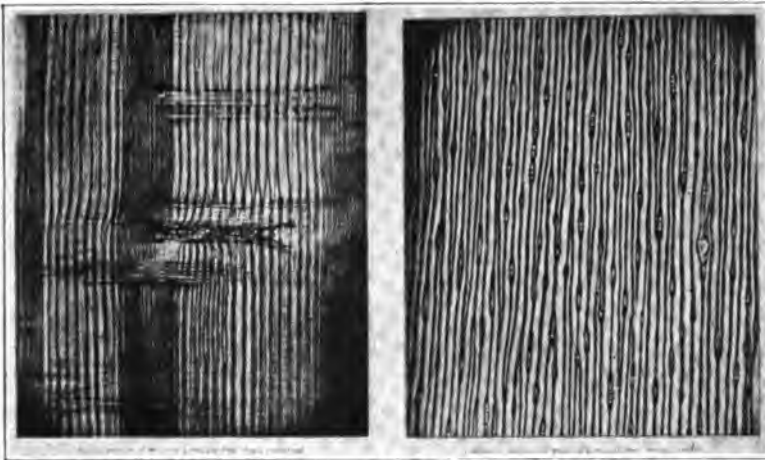
In this way dryness is obtained, for instead of additional moisture being injected into the blocks, the original moisture is extracted from them. Timber increases in strength as the moisture is reduced. The result is that blocks treated by this process are of greater strength than blocks subjected to steaming.

In the treatment of poles, piling, etc., it is necessary to get a lateral penetration against the fibers. To accomplish this the timber must be subjected to high steam heat so that there shall be, to a certain extent, a breaking down of the wood structure. But this severe treatment is not necessary in order to get penetration in paving blocks which are only 3 or 4 inches deep, because the oil enters the blocks thru the pores running parallel to the fibers of the blocks, and penetration is thus easily obtained.

This process of treating wood blocks was evidently copied from the process for treating poles, piling, etc. It must have been assumed that the process that was suitable for treating poles and piling would answer for treating paving blocks. But this is a grave error and should not be continued.

Creosoted wood block pavement resolves itself into three factors: First, the wearing material, which is the wood; second, the protective material, which is the oil; third, the method of applying the oil to the wood block.

The first factor is the wood. Yellow pine, while not the only suitable wood, is the principal one from which blocks are manufactured and used for the wearing surface. It is sufficiently strong for the heaviest traffic, but its composition is such that it does not retain its strength when exposed in pavements to the natural elements. The blocks made from it, or from any other of the suitable woods, have the initial strength for permanent and durable pavements, but the great weakness is that the fibrous structure of the blocks is very susceptible to the deteriorating influences of moisture and decay. (See Plates VI and VII.) The fibrous structure must be protected, for it is this protection alone that enables blocks made



VI. Tangential view of long leaf yellow pine fiber.

VII. Radial view of long leaf yellow pine fiber.

These plates show the wood structure. Observe the fibers and voids. Into these voids destructive agencies enter. The strength of the wood is, of course, in the combination of the fibers, and to retain this strength the fibers must be made proof against destruction by the natural elements. This is the object sought in treating the fibers.

from this fibrous structure to respond successfully to the conditions exacted of them as paving material. This result is entirely possible if the blocks are manufactured under a proper specification. It does not follow if blocks are simply preserved against decay or germ attack that they will make a good pavement. The expansive and contractive properties of the blocks and the weakening effects upon the fibers caused by absorption of moisture are what must be guarded against; the protection against decay automatically follows.

The more resistant the blocks are made to water, the better the pavement. Absorption of water means expansion; the subsequent drying means contraction. The absorptive blocks take up and give up moisture, as moist or dry conditions prevail. An illustration of the seriousness of this weakness is observed in blocks taken from a pavement on Wabash avenue, Chicago, laid under Tar Oil specification, gravity up to 1.08 degrees C. (See Plates VIII, IX and X.) These blocks were 4 inches deep and when taken up had been in service three years, having been laid in October, 1913. You will see the similarity in the way they crushed down to that of the blocks steam saturated and crushed down under pressure as shown

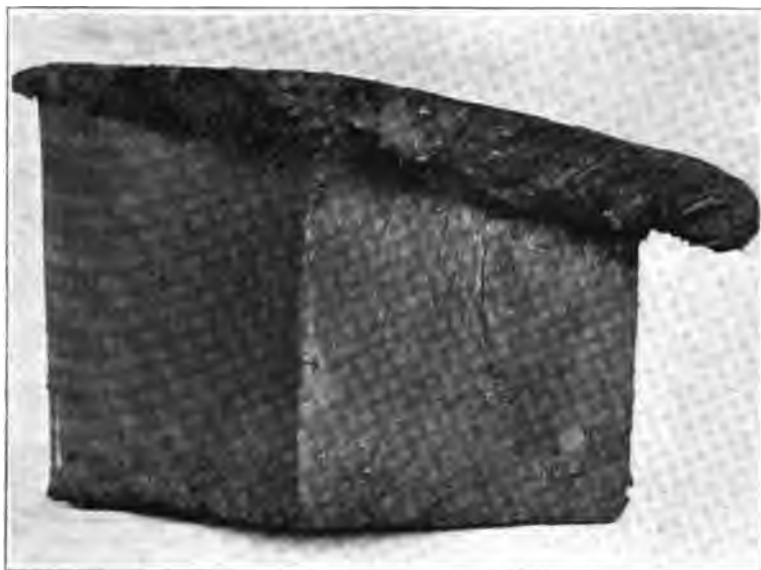
in Plate IV. These blocks were in the roadway in a place where they were subjected to much moisture, and the compression you see is the result of this moisture weakening (reducing the strength of) the fibre. If the treatment could have held the fibre close to its dry strength the blocks would have worn down and not have mashed down as here shown. (For Wabash Avenue oil specification, see Appendix.)

A pavement made of untreated wood blocks would immediately begin to deteriorate and would soon be destroyed; made from improperly treated wood blocks, the destruction would be relative. Neither untreated nor improperly treated wood blocks should be used. It is, therefore, most important that the treatment of wood paving blocks should be for the purpose of overcoming, to the fullest extent, the defects sure to arise from untreated or improperly treated blocks.

The second factor is the protective material, and it is the vital



VIII. Plates VIII, IX and X are companion pictures. The blocks were taken in September, 1916, from a pavement in Wabash Ave., Chicago, laid in October, 1913. The blocks were thoroly treated with a mixture of creosote oil and coal tar. They were greatly weakened by absorption of water. The blocks show thoro penetration of the preservative liquid. They were made proof against germ attack, but not proof against the destructive elements to which a pavement is continuously subjected.



IX. Same as Plate VIII. The block shown here was also taken from Wabash Ave. at the same time as that shown in Plate VIII.

material. Without it there could be no permanent wood block pavements. A pavement made from wood blocks untreated with a protective material, would immediately begin to deteriorate and would soon be destroyed; made from wood blocks treated with a deficient or improper protective material, deterioration would be delayed only. No wood blocks inherently defective should be used in making a pavement.

Wood is a product of nature; oil is the product of manufacture. It is axiomatic that if a permanent result is to be produced, the material itself, which is expected to produce the permanent result, must be permanent in character; and, not only that, it must be unchangeable in character and it must have fixity of quality, as well as permanency.

There are many examples of creosoted wood block pavements which show the result of using a material in which fixity of quality and permanency were absent in the treating material. In Plate XI is shown a wood block pavement alongside the Stutz automobile factory in Indianapolis. When the pavement was laid, a residence



X. Same as Plates VIII and IX. The block shown here was also taken from Wabash Ave. at the same time as those shown in Plates VIII and IX.

occupied the site on which the Stutz factory now stands, and at that time the sidewalk consisted of brick with sod on either side of it. When the Stutz factory was built, it was decided to make the sidewalk entirely of concrete. The expansion of the wood blocks on this street was so great in the center of this piece of property that in drawing a straight line from the inner edge of the curb line, it was necessary to fill in a patch of concrete between this line and the original curb at the west end of the property. This result is clearly shown in the picture. The dark spot in front of the automobile is a bulge in the pavement, the bulge being broken and the blocks loosely piled. This bulge would not have occurred if the sidewalk were not of rigid concrete. If the sidewalk had been of earth, the pavement, instead of bulging and breaking, would have forced the curb further back.

Another result of the lack of permanency in the treating material is shown in Plate XII. Here the expansion was so great as to cause a break in the cement curb and in forcing back the gutter into the earth caused the cement walk to rise several inches above

the original position, which had been designed to drain to the gutter. The straight edge will show the elevation of the walk due to expansion.

Plate XIII shows a row of blocks forced up at the curb line, due to expansion. You will note from the plate that all the blocks here shown are in a good state of preservation, and, as Plates XI and XII prove, a block preserved only against decay does not answer the requirements of a perfect block for wood paving purposes.

Plate XIV. The blocks shown in this plate have been in use for nearly fifteen years and during that time they have been a source of trouble due to expansion. Plate XIV shows a ridge just outside the gutter line due to expansion of the blocks. There has



XI. Note the concrete patch between the outer line of the walk and the inner of the curb, made necessary by the expansion of the blocks, which pushed back the curb in the center.

been a row of 4-inch blocks parallel to the curb taken from this pavement and still the expansion continues. The straight edge shows that because of this expansion, the drainage, instead of reaching the gutter, remains on the body of the pavement quite a distance from the gutter. The curb line in this street has been totally destroyed. It is pushed back several inches and is in zigzag fashion the entire length of the street, as shown in Plate XV.

Plate XVI is a companion of Plate XV, showing the body of the street. It will be observed that these blocks are in an excellent state of preservation against decay. But, considering the continual bulging of the pavement and the destruction to the curb line, it cannot be said that the blocks were treated with a proper material for paving purposes, and, especially so, as this disturbance to the pavement and the curb line will always continue.

The third factor is the method of preparing the wood and of applying the oil, which features are mechanical and relate only to the handling of the materials entering into the pavement. Good and bad materials are handled in the same manner, and at the same expense as to operation. The heating and drying of the wood can be compared to the heating and drying of the mineral aggregate entering into an asphalt pavement. The heating and drying, of course, must be properly done. But altho the heating and drying of the material comprising the wearing surface are done properly, yet if an improper binding and protective material is used, whether in an asphalt pavement or in a wood block pavement, failure is sure to follow, because proper methods of manufacture of products where improper materials are used cannot make perfect goods. It requires the combination of proper materials and proper manufacture to produce the required results.

It is a fundamental principle that the mechanical work in any operation should be properly done; and while one hundred per cent. efficiency is not always reached in this respect, yet mechanical operations can be very nearly perfectly done and can be pretty well controlled by proper appliances and supervision. So we shall assume that the manufacturing is done perfectly, within reasonable limits, and that if an error is made in the manufacture, and failure results therefrom, the manufacturer and not the material should be held accountable therefor. But if an improper material be used



XII. Here the expansion of the pavement was so great that it shattered the cement curb, and raised the walk several inches above its original position.

for the vital part of the work, it constitutes an inherent defect in the work which cannot be corrected. With the strength of the wood established, the vital part of a creosoted wood block pavement is the oil, and unless the proper oil is used, failure, either comparative or complete, will follow.

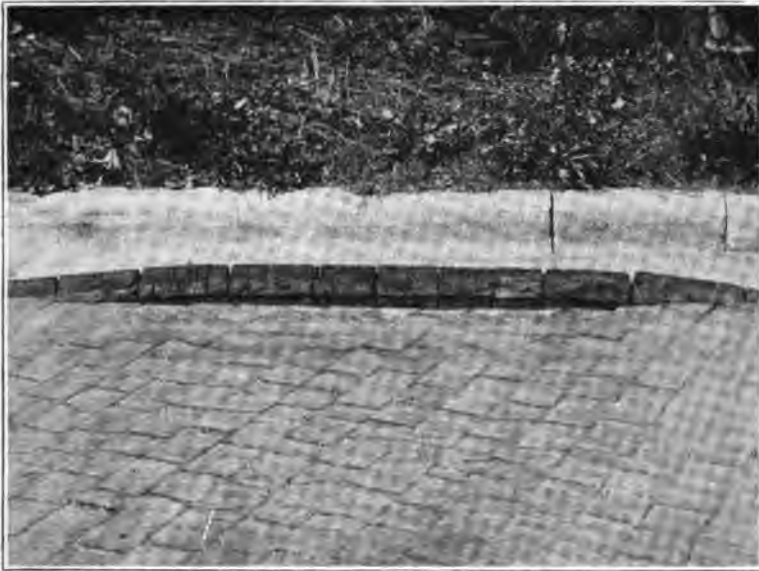
In every form of artificial material, whether of steel, concrete or brick, and especially where the resulting work is exposed or subjected to severe usage, the highest grades of materials are demanded. If steel were to contain a mixture of partly refined iron it would not be acceptable; if brick contained imperfectly burned clay it would not be acceptable; concrete made from inferior cement would not be acceptable. While unrefined iron has a close relation to steel, imperfectly burned clay a close relation to the properly finished brick, and the quality of the cement a direct relation to the concrete, yet if these materials (inferior and superior) are mixed, it is not for the purpose of obtaining as good a material as the best, before mixing, but for the purpose of "unloading the poor material on somebody." The relation of the good and bad of these

materials cannot be, and never is, advanced as a reason why either of these materials, combining the perfect and imperfect, could or should be used.

There exists in the creosoted wood block paving industry a situation parallel to the illustration just cited. It is the belief that coal tar, if the water is removed from it, can be mixed with creosote oil without injury to the creosote oil, because creosote oil is obtained from coal tar; that is, that the mixture is comparable in quality with the distillate or refined creosote oil. This is so thoroly wrong that it seems almost unnecessary to comment on it. Creosote oil is the refined material. Coal tar is its source; yet creosote oil does not exist in coal tar to a very great extent as such, altho it is obtained from coal tar, but it is mostly a decomposition product obtained by distillation and cannot be found in the tar originally.

Coal tar is a very viscous material and of itself cannot penetrate the timber. To bring it to a state of sufficient liquidity so that it can be made to penetrate wood, a light volatile creosote oil is used as a solvent. This creosote oil, because of its inferiority, would not be used alone for paving purposes; neither would the tar be used alone, even if it had penetrative properties, because it has not the proper qualities for wood preservation. It contains a large percentage of volatile material. These two materials in mixture will produce no better results than either of them alone; the mixture is no better than the individual materials. High gravity and high boiling point of creosote oil indicate degree of quality, and by some people it is figured "by the use of numerals," that is, if the great weight of coal tar were added to the light creosote oil the resultant mixture would have a gravity comparatively as high as the creosote oil and that the mixture would also have a high-boiling point, and that, therefore, the mixture must be the same thing as the high-grade creosote oil. One might just as well say that because the gravity of one part of tin and three parts of lead is the same as silver, the mixture is silver.

A paving material is indeed a most exposed material. It is exposed to every kind of climatic condition; heat, cold, freezing, thawing, moisture, drouth, and to severe compression, torsion stresses and other natural conditions. Primarily and necessarily it should consist of a material or materials which will effectively



XIII. Row of blocks along the gutter forced out by expansion of the blocks in the street.

and permanently resist these agencies of destruction. To use a material largely volatile in an exposed position is too unsound for technical men or users to consider doing so. Only by the use of the most stable material can a wood block pavement be successful in resisting these destructive agencies and obtain the full mechanical life of the pavement. Whether a paving material should be made from stable material or volatile and chemically changing materials permits of but one answer and that an unequivocal one, namely, the stable material suited to the purpose must be used.

I have permitted coal tar to volatilize for a period of six months, at the end of which period the pitch (residue) was so brittle and friable at a temperature of 40 degrees F. as to break readily by a slight fracture at this temperature. The pitch is a coating and not a penetrant to the fibre and if it becomes brittle and breaks, water enters the fibre and rests there; even if, during warmer weather, the pitch should unite again, it does not alter the weakened condition with respect to the fibre.

I have here for illustration a mixture of No. 1 Maintenance of

Way creosote oil and a good coke oven tar. The evaporation from the oil in 180 days was 70.8 per cent.; the evaporation from the tar during the same period was 23.10 and the evaporation of the two materials mixed together in proportions of 41 parts of tar and 59 parts of oil was 48.7 per cent.

Maintenance of Way (English) Creosote Oil.

Specific gravity at 38 degrees C.....	1.040
Distillation to	
200 degrees C.....	3.0
210 degrees C.....	5.5
235 degrees C.....	31.5
250 degrees C.....	48.0
285 degrees C.....	67.5
315 degrees C.....	80.0
335 degrees C.....	85.5
355 degrees C.....	90.0
Specific Viscosity (Engler).	
Oil 82 degrees C., water 20 degrees C.....	1.085
Evaporation 49 degrees C.	
In 3 days.....	20.47
In 6 days.....	28.96
In 9 days.....	36.75
In 12 days.....	43.77
In 15 days.....	46.84
In 18 days.....	49.68
In 180 days.....	70.85

Coal Tar (Coke Oven).

Specific gravity at 38 degrees C.....	1.160
Distillation to	
200 degrees C.....	0.5
210 degrees C.....	2.5
235 degrees C.....	9.0
250 degrees C.....	11.5
285 degrees C.....	19.5
315 degrees C.....	25.0
335 degrees C.....	29.0
355 degrees C.....	35.0
Specific Viscosity	
Oil 82 degrees C., Water 20 degrees C.....	2.267
Evaporation 49 degrees C.	
In 3 days.....	8.73
In 6 days.....	11.36
In 9 days.....	13.34
In 12 days.....	15.00
In 15 days.....	15.76
In 18 days.....	16.48
In 180 days.....	23.10

	English Creosote	Coke Oven Coal Tar
Specific gravity 38 degrees C.....	1.040	1.16
Distillation to		
200 degrees C.....	3.0	0.5
210 degrees C.....	5.5	2.5
235 degrees C.....	31.5	9.0
250 degrees C.....	48.0	11.5
285 degrees C.....	67.5	19.5
315 degrees C.....	80.0	25.0
335 degrees C.....	85.5	29.0
355 degrees C.....	90.0	35.0
Specific Viscosity (Engler)		
Oil 82 degrees C., Water 20 degrees C.....	1.085	2.267
Evaporation 49 degrees C. in 180 days.....	70.85	23.1

SPOT TESTS FOR DETERMINING ADULTERATION OF PURE COAL TAR CREOSOTE WITH TAR

Pure Coal Tar



Creosote

Pure Coal Tar Creosote



With 5 % Tar Added

Pure Coal Tar Creosote



With 25 % Tar Added



The evaporation of these materials for a period of 180 days when calculated in the proportions of 41 parts coal tar and 59 parts creosote oil was 51.27 per cent.

In combination in the same proportions and under the same exposure of 180 days, evaporation was 48.70 per cent.

The evaporation tests shown in the tables are for a good grade of ordinary creosote oil and much better than would be used in the tar mixture under the proposed specifications. The coke oven tar is also of a very good grade. The evaporation from a creosote oil lighter than the above would reach 85 or 90 per cent. under the same exposure. This is, for 180 days, at 120 degrees F. Even if coal tar were a good material, the fact that it is not a constant material, but a most variable material, would preclude its general use for paving; because from a material that is not constant only an unconstant and variable product would be produced, and good engineering, of course, requires that only a paving material that is nearly uniform in quality should be used.

With the cost of the two materials being in the relation of two to one, for the stable (Ideal) oil as against the mixture, the actual cost of the proper material, because of its stability, would be ultimately less than that of the inferior material.

Ideal Creosote Oil.

Specific gravity 38 degrees C.....	1.138
Distillation to	
200 degrees C.....	0.0
210 degrees C.....	0.0
225 degrees C.....	0.0
250 degrees C.....	0.0
285 degrees C.....	1.5
315 degrees C.....	6.0
335 degrees C.....	16.5
355 degrees C.....	32.5
Specific Viscosity (Engler)	
Oil 82 degrees C., Water 20 degrees C.....	1.511
Evaporation 49 degrees C.	
In 3 days.....	0.46
In 6 days.....	0.51
In 9 days.....	0.84
In 12 days.....	0.92
In 15 days.....	1.22
In 18 days.....	2.04
In 180 days.....	9.10

Probably one of the most emphatic examples of the limitation of the use of creosoted blocks, due to deficient preservative and protective material, is the fact that the street railway companies, pre-



XIV. Bulge along the gutter line which prevents drainage reaching the gutter, forcing it to remain on the pavement until it evaporates or is absorbed by the blocks.

viously very much in favor of creosoted wood block, now almost universally object to their use in the tracks because of the disturbance they cause to the rails. Without collecting any figures on the subject, but using for my opinion as a basis the cities where wood blocks are being used, where the street car companies now object to their use in their tracks, I would say that the output of creosoted wood blocks is lessened possibly by 20 per cent. In the particular cities I have in mind, the cost did not enter into the question at all, for granite was substituted for wood blocks at a cost greater than that of creosoted wood blocks. The insertion of a granite block pavement in the middle of the street with the other portion paved with creosoted blocks, presents an unfinished appearance to the street. Creosoted wood blocks can be produced so that there will be no disturbance to the rails in any track, but, of course, this cannot be done by using a material that is volatile and changeable in character.

The specifications for the proper material should include reasonable safeguards to protect it from adulteration. It is difficult

to anticipate all possible materials for adulterating creosote oil, but the common adulterant is coal tar, and it can be most effectively guarded against by a simple test, namely, the color or spot test. The color of creosote oil is amber; it retains that color until it is adulterated or manipulated or abused in such a way as to change its color, and it should neither be adulterated, manipulated or abused. The addition of coal tar to creosote oil shows up readily under the color test, both in the oil itself and especially in the residue at 355 degrees C. This color or spot test is also used for detecting tar adulteration in creosote in other channels of trade. I will read a report from the *Iron Age* of May 25, 1916, reporting a meeting of the Diesel Engine Users Association of England, at which the spot test was adopted for determining the presence of tar in the oil.

TAR AND TAR OIL AS DIESEL ENGINE FUEL.

(From *Iron Age*, May 25, 1916.)

At the February meeting of the Diesel Engine Users' Association, England, W. Batho, British representative of Sulzer Brothers, Win-



XV. Gutter and curb thrown out of alinement by the expansion of the blocks.

terthur, Switzerland, gave some particulars of tar oils and tars suitable for use as fuel in Diesel engines. Almost all heavy oils can be used, according to the report of his remarks in London *Engineering*, altho a certain amount of crystallization occurs in some of them after storage in cold weather. Heating the oil would usually dissolve the crystals readily, and this should be done, as they contain elements of high fuel value.

The minimum calorific value varies from 15,800 to 16,500 B.t.u. per pound and the flash point from 70 to 130 deg. Fahr., it being considered undesirable from the point of view of safety against fire to employ oil having flash points below 100 deg. *When dropped on white filter paper the oil should spread without leaving any black residue, indicating a large percentage of free carbon or other tar ingredients.* The residue only begins to evaporate at 400 deg. C. and can lead to a considerable amount of deposit in the engine cylinder, thus necessitating frequent cleaning and grinding in of the exhaust valves. The amount of ash or water present does not exceed 1 per cent. in either case, and the sulphur content should range between $\frac{1}{2}$ and 1 per cent.

(See color plate for practical illustration of the color of spot test.)

It is just as reasonable a test as if you were to buy white paint and insisted that the paint should be white and you insisted upon its being white. It is no greater hardship for the manufacturer of creosote oil to keep the oil an amber color than it is for a paint manufacturer to keep white paint white.

The tar acids and sulphonation tests and gravity requirements of certain fractions of the distillate should be included in every coal tar creosote oil specification, for these tests are protection against adulteration.

The proper oil for creosoted wood block pavements, as its name signifies, must be creosote oil. It must be antiseptic; it must have the qualities of permanently protecting the wood fiber of the blocks against the natural elements, and, by "permanently" is meant, that it shall give to the fibers substantially the same protection, as fully and completely, after years of exposure, as when the blocks are first made and laid; it must undergo little or no chemical change, for the pavement should be the same thruout its time. The use of any oil that is volatile in character brings its own retribution. Because of the well-known law of physics that "Nature abhors a vacuum," the space will become filled with something, and that

something in a paving material is one or more elements which are destructive to the fiber of the wood. When an oil evaporates from the wood, it will be replaced by destructive elements; hence the oil must have the powers of penetration so that it will enter the minute cells of the fiber of the wood and remain there. A material which evaporates or which has the property of only coating outer surfaces of the wood blocks, as if they were painted, should not be used, but the oils used should have the properties of permanently and closely adhering to the fiber thruout the entire body of the blocks. The oil which chemistry has produced for us and which experience has proved to us is capable of fulfilling these results is a high distillate creosote oil from coal tar. It has stability, it has the antiseptic qualities, it has the qualities of firmly uniting with the wood fiber and its chemical composition undergoes very little or no change.

APPENDIX.

*Specification for Coal Tar Creosote Oil Used in Wabash Ave.,
Chicago, Illinois.*

1. It must be obtained entirely from coal gas or coke oven tar, and must not contain any admixture of any tar oil or residue obtained from petroleum or any other source except coal gas or coke oven tar.
2. It must be completely liquid at 38 degrees C., and not more than three (3) per cent. of water-free oil shall be insoluble in chloroform or benzol.
3. The specific gravity of the oil at 38 degrees C. (100.4 F.) must be at least 1.03 and should not exceed 1.08.
4. It shall be subject to a distillation test as follows:

The apparatus for distilling the oil must consist of an ordinary c.cm. distilling flask having a side neck not over 2 inches above the body of the flask.

The bulb of the standardized thermometer shall be $\frac{1}{2}$ inch above the surface of the liquid in the flask and during the progress of the distillation it shall remain in the position as originally placed. The distance between the thermometer bulb and the end of the condensing tube shall be 22 inches. The bulb of the flask shall rest on an asbestos board at least 6 inches square, thru which a round hole has been cut 2 inches in diameter. This hole is to be further en-

larged by cutting 6 notches around its circumference, these notches to be $\frac{1}{2}$ inch deep. The bulb of the flask shall also be protected so as to prevent excessive heat radiation by placing around it an asbestos cylinder 4 inches in diameter and 3 inches high; and resting on this shall be a piece of flexible asbestos board of sufficient size to fully cover the cylinder; said cover having a slit cut from the outer edge to a round hole in the center to admit the neck of the flask.

The distillation shall be continuous and at the rate of 1 to 2 drops per second.

One hundred grams of the oil shall be taken and all percentages determined by weight on the basis of dry oil.

Tested in the above manner, it shall give no distillate up to 200 degrees C.; less than five (5) per cent. up to 210 degrees C.; less than twenty-five (25) per cent. up to 235 degrees C.; less than thirty-five (35) per cent. residue at 355 degrees C.

5. The distillate between 210 degrees and 235 degrees shall, on cooling to room temperature (77 degrees F.) yield solids.

6. The oil shall not contain more than three (3) per cent. of water.



XVI. Companion picture to Plate XV. The blocks show no rot or decay. Had these blocks been treated with a proper preservative and protective material the gutter and curb lines would not have been affected.

THE TREATMENT OF WOOD PAVING BLOCKS.

By Clyde H. Teesdale, Engineer in Forest Products, Forest Products Laboratory, Madison, Wis.

In discussions of wood block paving specifications the principal consideration has in the past been given to the properties of the oil. So much attention has been paid to this factor that it seems possible the importance of the method of treatment has been underestimated. Engineers are now, however, coming to realize that the treatment of the blocks is possibly the most vital consideration in the successful construction of wood block pavements. Upon the care used and the method adopted for handling the blocks thru the treating cylinder will depend to a large extent the ultimate durability of the pavement and its freedom from the troubles of bleeding and expansion. From the standpoint of durability, the process of treatment is possibly of greater importance than the quality of the oil, as even the highest obtainable grade of coal-tar creosote will not prevent decay if it is poorly distributed thru the wood.

The essential features in the proper treatment of the blocks consist, first, in obtaining so far as possible an even and thoro diffusion of the oil thru each block, and, second, in so controlling the operations of treatment that subsequent bleeding and swelling of the pavement will be reduced to a minimum. For these reasons it is felt that much more consideration should be given to specifications for treatment than has been done in the past, and possibly less speculation as to the exact quality of oil which ought to be used.

In selecting a preservative its penetrating qualities must, of course, be considered. The results of some experiments made at the Forest Products Laboratory on the penetrability of mixtures of creosote and coal-tar were published in 1913.* Briefly, it was shown that the penetration of creosote into longleaf pine was retarded when coal tar was mixed with it, and that this retardation became greater as the per cent of tar was increased. Penetration was

*"Some Tests to Determine the Effect on Absorption and Penetration of Mixing Tar with Creosote," by F. M. Bond, p. 216, Proc. American Wood Preservers' Association, 1913.

also retarded by free carbon. There was a great difference in the penetrating properties of tars from different sources, and those tars which normally contained the lowest contents of free carbon penetrated the best, even after the free carbon was removed.

Since publishing the above results, the work on penetrations and absorptions was continued. The later data have not yet been published, and this opportunity is taken to make some of the results available altho they should be used in conjunction with the previously published tests. In this work penetrance tests, made on 2-in. by 4-in. by 2-ft. specimens, and impregnation tests on paving block specimens were made.* Some of the results obtained in these tests are given in Figures 1 to 7. In general, the additional work confirmed the results obtained in the previously published tests. Thus Figure 1 shows how in penetrance tests the penetration and absorption in longleaf pine were decreased as the per cent of tar increased. The additional work was principally, however, a study of the effect of changes in treatment on penetrations and absorptions.

For example, the results of some impregnation tests are given in Figure 2 on three mixtures of creosote and tar from which the free carbon had been removed.† In each case, the absorptions were approximately the same, the time of treatment and pressure being increased as the percentage of tar was raised. The absorptions obtained are shown at the top of the chart. Figure 3 shows in a similar manner the effect of increasing the free carbon in a given mixture. In both of these cases the resistance to treatment is indicated by using the product of pressure in pounds and time in minutes. The influence of the time and pressure variables taken is shown in Figure 4 for impregnation tests on paving blocks, and in Figure 5 for penetrance tests. The paving blocks in each case were given an absorption of 6 pounds per cubic foot. The penetrance tests (Figure 5) were then made using the same pressures, times and temperatures as in the impregnation tests of Figure 4. Another test in the penetrance apparatus is given in Figure 6, which, so far as possible, each piece was given the same absorption. In

*See appendix for methods of conducting tests, apparatus used and for properties of oils used.

†The method of removing free carbon was the same as that followed in the tests published.

Figure 7 is shown the effect of increasing the temperature of the preservative. Thus an increase in temperature from 160° to 220° resulted in an increase of 2-1/7 times the absorption and 1.8 times in penetration, in penetrance tests. These relations are not directly comparable to commercial practice, however, but simply indicate greater penetrability with rise in temperature.

The essential feature to be noted in these experiments is that it was possible in the impregnation tests on paving blocks to obtain the required absorption of 16 pounds per cubic foot even when the per cent of tar was greatly increased. In most cases this could be done by either increasing the time of treatment or the intensity of pressure. It was found in general that for a given absorption of oil better penetrations were obtained with lower pressures and longer treatments than with higher pressures and shorter treatments. Increasing the oil temperatures was very effective for improving both penetrations and absorptions.

Summarizing the results, it can be stated that those tars produced at a low temperature and containing normally low amounts of free carbon retarded penetrations the least. Removing the free carbon increased the penetrability of the oil. Good penetrations were obtained when tar was added to creosote by increasing the time and intensity of pressure. In such cases a given absorption could be quickly obtained by raising the pressure, but the best penetrations were secured by increasing the time of treatment. Raising the temperature of the oil assisted both penetration and absorption. In applying these results to treating plant practice, it may be said that the best penetrations are obtained with high oil temperatures and by using a long pressure period at low pressures rather than a short pressure period and high oil pressures.

The methods which are followed in handling paving blocks in the treating plant have a very important bearing on the subsequent development of bleeding and swelling troubles. Previous work on this subject was published in the 1914 proceedings of this association and with additional results was published in the 1915 proceedings of the American Wood Preservers' Association. It was found in this investigation that bleeding could be greatly reduced by using a vacuum before the oil pressure treatment and also after treatment, known technically as the preliminary and final vacuums. A reduc-

tion in bleeding could also be obtained by steaming the timber before treatment. This was more effective on tar and creosote mixtures than on creosote. Absorptions of oil of over 16 pounds per cubic foot tended to increase bleeding. It was also found that rapid-growth loblolly-pine blocks bled excessively. There was not a great difference in the bleeding obtained with creosote or with the tar and creosote mixtures. When the blocks were steamed and given a preliminary and final vacuum treatment the tar and creosote blocks had a tendency to bleed less than those treated with creosote. It was found that a final steam and vacuum treatment after the oil pressure period would clean tarry and carbonaceous matter from the blocks.

Subsequent to this work a further series of tests* was made in which the amount of bleeding obtained from a variety of oils was studied. These oils were injected into seasoned blocks by the steaming and vacuum method. The method of conducting the tests in this case was the same as that in the previous work. (See appendix for method of conducting the tests, and properties of the oils used).

The data on absorption and bleeding are given in the following table. It will be noted that in no case was the bleeding over 5 per cent of the absorption. In the previous work where no preliminary or final vacuum or steaming treatments were given, the total bleeding ranged from 9 to 23 per cent. It is also to be noted that coal tar creosote and carbolineum bled more than those oils containing tars, (3.8 per cent and 4.3 per cent respectively). The creosote and crude oil mixture bled 2.53 per cent while all of the other mixtures showed less than 1½ per cent.

Results Obtained on Bleeding and Swelling Tests Using Various Grades of Oil.
Average absorption of

Description.	of oil by blocks Lbs. per cu. ft.	Total bleeding % of absorption	Total swelling % increase in area
Coal tar creosote.....	14.8	3.77	2.96
Coal tar	14.2	1.43	2.85
Water gas tar	17.5	1.15	2.14
Carbolineum	14.1	4.92	2.84
25% coal tar, 75% creosote	17.9	0.91	3.18
50% coal tar, 50% creosote	15.9	1.27	2.90
25% water gas tar, 75% creosote	17.0	1.31	2.48
50% water gas tar, 50% creosote	18.7	1.30	2.80
50% asphaltic crude oil, 50% creosote	14.7	2.53	2.52

*These experiments were conducted by Eugene ReQua in co-operation with the University of Wisconsin.

In the previously published work on the swelling of paving blocks the main features noted were that the rate of swelling was slower in treated blocks than in untreated ones, although in all cases treated blocks showed considerable swelling. Mixing tar with the oil retarded the rate of swelling. From 50 to 75 per cent of tar was necessary, however, to appreciably retard or reduce the total amount. Free carbon apparently had no effect. Very heavy tars retarded swelling more than lighter ones. Increasing the absorption above 10 pounds had little influence.

At the time the additional work on bleeding was done, further tests on swelling with the same oils were carried on. These tests were made exactly as described in the previous work, which, in brief, consisted in placing the blocks in a tank of water and allowing them to soak until they ceased to increase in size. Measurements were made at suitable intervals of the length and breadth of the blocks. The results were given in the per cent increase in area of the transverse section of each set of blocks.

These blocks were treated with the same oils and at the same time as the ones described above for bleeding tests (see appendix). Four seasoned blocks were used with each oil and those treated with different preservatives were so cut from the original stock that they were matched with each other as to moisture content and growth conditions. It will be noted that the results (see table) are all within 1 per cent of each other, which indicates that the character of the oils used did not have a very great influence on the subsequent swelling.

The results of the experiments made at the Forest Products Laboratory have led to the following conclusions concerning the selection of timber, oil, treatment and laying of wood block paving, made from southern yellow pine. These conclusions must be considered tentative, at least for the present, until greater experience with these methods has been obtained.

1. *Woods.* It is preferable to use green timber altho seasoned stock may be used by proper handling. The advantage of using green stock is the greater certainty of having the blocks expanded to their maximum size when they are laid in the street. Green timber also requires a thoro steaming before it is in a suitable con-

dition for receiving the oil, and, hence, there is less incentive for omitting this portion of the treatment. Rapid-growth blocks are undesirable, not only from the point of view of subsequent durability of the pavement, but also because they take an inferior treatment and appear to bleed more than those which are of slow growth. Rapid-growth heart pine takes good treatment in the summerwood bands but the springwood bands are liable to have very poor penetrations. If the blocks are of very rapid growth this results in considerable areas which are untreated. This is not only undesirable because their durability is questioned but also because such blocks are more liable to take up water and expand.

2. *Preservatives.* Dry blocks treated with either creosote or with tar and creosote mixtures will take up water and expand. The main function of the oil, therefore, is not to waterproof the blocks but to preserve them from decay. Any fairly good grade of oil which will permanently accomplish this purpose and which can be thoroly diffused thru the wood should prove satisfactory. When tar mixtures are used the tars selected from those produced at low temperatures and containing small amounts of free carbon have given the best penetrations. Preferably the free carbon should be removed. Too much tar in the mixture is not desirable if the best penetrations are to be expected. It has been found that bleeding may occur with oils having widely differing properties, and that by proper methods of treatment the bleeding may be greatly reduced. The method of treatment is therefore, of greater importance than the oil when considering the bleeding problem, as this may be handled in the treatment specifications. However, it should be borne in mind that if any bleeding occurs the presence of a tar paving oil on the pavement is more objectionable than an equal amount of creosote, because of its sticky and adhesive character.

3. *Treatment.* A most important consideration in a paving block specification is the care which should be taken in treatment. The first step of treatment is to thoroly steam the timber. This should be followed by a strong vacuum. If green timber is used the steaming and vacuum remove the excess moisture from the wood and prepare it for the oil. These steps also remove excess air from the cells, which is one of the principal causes of bleeding. It is desirable to steam seasoned timber, because moisture is added to the

wood and the blocks are brought more nearly into the expanded condition, thus decreasing the possibility of swelling troubles. If the timber is not evenly seasoned the steaming will also tend to bring it to a more uniform moisture condition. Steaming and vacuum on dry timber, just as in the case of green stock, remove much of the air from the cells and reduce bleeding.

The oil should be admitted to the cylinder without breaking the vacuum, and the pressure gradually applied. It is important that the pressure should not be raised too rapidly. If high pressures and short pressure periods are used the tendency for some blocks to receive much more than their share of oil, while others receive less, seems to be greatly increased. Furthermore, this has a tendency to give poorer penetrations, which results in much oil being near the outside of the blocks and little oil in the centers. If the pressure is very gradually raised a longer time of treatment is required. This, however, has the effect of giving better penetrations with the same absorptions and results in a more uniform distribution of the oil thruout the charge. The method of operation during the oil pressure period, therefore, has a very important bearing on the ultimate durability of the blocks, and if this step of the process is properly carried out in conjunction with the other steps of the treatment it should be possible to satisfactorily use paving oils containing a suitable grade of tar.

When the required amount of oil has been injected into the blocks the pressure is removed and a final vacuum applied, the purpose of which is to remove excess oil from the outer fibers of the wood. It has been our experience that the oil removed by the final vacuum would come out of the blocks in time even if this were not applied. Sufficient oil must be injected during pressure to allow for the loss during the final vacuum.

If a preservative containing tar has been used it is often desirable to permit a final steaming and vacuum operation. This step removes dirt and tarry matter from the surface of the wood and makes the blocks bright and clean, even when oils containing much tar and carbon have been used. It also probably has considerable influence in retarding subsequent bleeding of tar mixtures.

APPENDIX.

EXPERIMENTAL METHODS.

The relative absorptions and penetrations were determined by two forms of tests:

1. Penetrance tests where the preservative was applied to a small area in the specimen and measurement made of the penetrations secured.
2. Impregnation tests, the specimens being treated with the preservative under pressure in a cylinder.

The penetrance tests were made primarily to obtain relative data on penetration, while the impregnation tests were conducted primarily to obtain data on the absorption of the preservative.

MATERIALS USED.

Wood—Thruout all of the experiments, selected air-dried commercial long-leaf pine was employed. The specimens used in the penetrance tests were approximately 2 by 4 inches in cross-section and of varying lengths (18 to 24 inches). Pieces cut from the same stick were regarded as matched and were designated as a set of specimens. Test pieces selected in this manner were considered more uniform in structure than unmatched material, hence, the variables introduced by differences in wood structure were reduced. From two to four sets of matched specimens were used in each series of tests, the results being averaged for each test. The specimens used in impregnation treatments were paving blocks 4 inches long cut from two sticks of air-dry commercial paving block stock approximately 4 by 8 inches in cross-section. In each of these tests a treatment was made on one block from each stick, thus giving two blocks treated with the same preservative. In all of the impregnation tests, the results for each treatment were averaged.

Preservatives—Six commercial coal-tar creosotes from different sources and of varying specific gravities and five coal tars from by-product ovens and gas house plants were used in the penetration experiments. The general characteristics of these preservatives were as follows:

PRESERVATIVES USED IN PENETRATION AND IMPREGNATION TESTS.

Coal-Tar Creosotes.

No.	Kind.	Sp. Gr. at 60° C.
1	Coal-tar creosote containing coal-tar (estimated at about 10%)	1.0483
2	Coal-tar creosote	1.0475
3	Coal-tar creosote	1.0576
4	Coal-tar creosote containing coal-tar (estimated at less than 5%)	1.0710
5	High boiling coal-tar creosote	1.1050
6	Coal-tar creosote	1.0470

Coal Tars.

No.	Kind.	% free carbon.
1	By-product coke-oven tar	6.0
2	By-product coke-oven tar	16.0
3	Gas house coal tar	30.0
4	By-product coke-oven refined	7.0
5	By-product coke-oven tar	14.0

DETAILED DESCRIPTION OF TESTS.

Penetrance Tests—Each specimen before test was placed on a shelf in the oven of the penetrance apparatus* and the temperature maintained at 160 degrees F. for 24 hours.

A hole 1 inch in diameter and either $\frac{3}{4}$ or 1 inch deep was bored in the specimen, after which it was weighed to 0.001 of a pound immediately before and after treatment. The specimen was then clamped into the apparatus and the preservative applied to the hole under pressure. The temperature of the oil and the specimen was the same in each case. The absorption of preservative by each specimen was determined from the difference in weights. The relative penetrations in the penetrance tests were determined by sawing each specimen longitudinally and transversely thru the center of the hole. Each specimen was sawed approximately 24 hours after treatment and the treated areas were measured by means of a planimeter. The average longitudinal penetration was determined from these measurements.

*See Proceedings American Wood Preservers Association 1913, page 220, for complete description of apparatus.

IMPREGNATION TESTS.

The blocks were air-dried in the laboratory for several months and consequently had a very small moisture content. Before treatment each block was weighed to 0.01 of a pound and the dimensions measured to 0.01 of an inch. The volume was determined from these measurements. After treatment each block was again weighed and the absorption in pounds per cubic foot computed.

BLEEDING AND SWELLING TESTS.

Oil No.	Description	Sp. Gr. at 60° F.	Free Carbon, %	Viscosity Engler at 82.2° C.	Remarks
1	Coal tar creosote	1.089	....	...	24% to 235° C. 21% residue at 360° C. Contained 5% tar.
2	Coal tar	1.180	12.94	7.24	
3	Water gas tar	1.087	trace	1.21	Trace of water— 21.6% to 235° C. 51.6% to 380° C.
4	Crude oil used in No. 10 (asphaltic base)	0.922	0.79	4.40	
5	Carbolineum	1.120	....	1.80	
6	75% creosote No. 1, 25% tar No. 2	Not analyzed			
7	50% creosote No. 1, 50% tar No. 2	1.145	8.58	1.80	
8	75% creosote No. 1, 25% tar No. 3	Not analyzed			
9	50% creosote No. 1, 50% tar No. 3	Not analyzed			
10	50% creosote No. 1, 50% asphaltic crude oil	1.010	3.17*	1.48	

Note—The oils used in the bleeding and swelling tests are shown in this table, together with some of their properties. None of these oils were filtered before using.

The wood used was air-dry longleaf pine cut up into blocks 4 by 4 by 8 inches. Four blocks were used for bleeding tests and four for the swelling tests in each case. The treatment given was as follows for each preservative:

1. Preliminary steaming, 20 pounds, for 1½ hours.
2. Vacuum 26 inches for one hour.
3. Blocks removed and weighed.
4. Vacuum 26 inches for 15 minutes.
5. Oil pressure.
6. Final vacuum 26 inches for 15 minutes.

After treatment the blocks were allowed to dry at room temperature for 24 hours, after which they were placed in an oven in tin boxes and subjected to a constant temperature of about 120° F. until the oil ceased to bleed from them. Blotting paper was used to absorb the oil as it came from the blocks, weights being taken at suitable intervals. The bleeding test with each preservative was made on four blocks. The blocks used for the different preservatives were matched with each other so that the results were comparable.

The results of work done at the Forest Products Laboratory on paving block treatment have been published in the following three papers:

1. "Some Tests to Determine the Effect on Absorption and Penetration of Mixing Tar with Creosote," by F. M. Bond, Proceedings of American Wood Preservers' Association, 1913.
2. "The Bleeding and Swelling of Wood Blocks," by C. H. Teesdale, Proceedings of American Society of Municipal Improvements, 1914.
3. "The Bleeding and Swelling of Paving Blocks," by C. H. Teesdale, Proceedings of American Wood Preservers' Association, 1915.

*This was not free carbon, but a precipitate thrown out of the crude oil when the creosote was added.

PENETRANCE TESTS

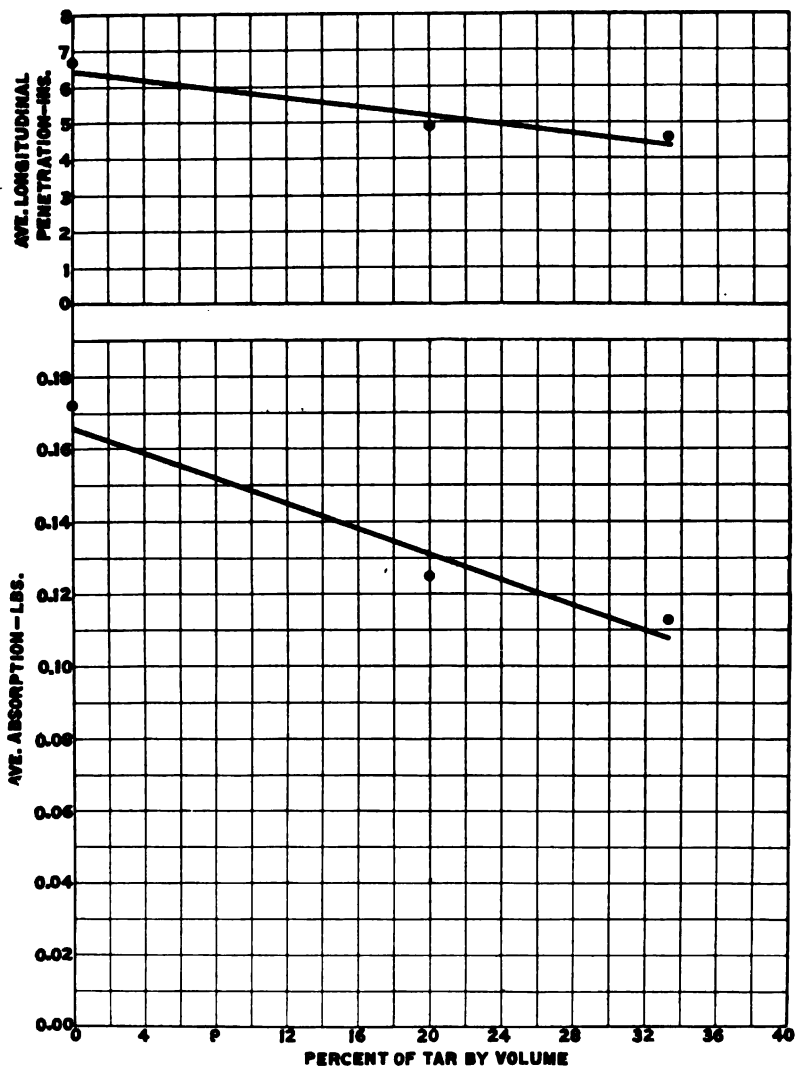


Figure 1.

Absorptions and penetrations in heart longleaf pine using mixtures of tar No. 4 and creosote No. 6. Time of treatment, 2 hours; pressure, 80 pounds per square inch; temperature of preservative, 180° F.

IMPRECINATION TESTS

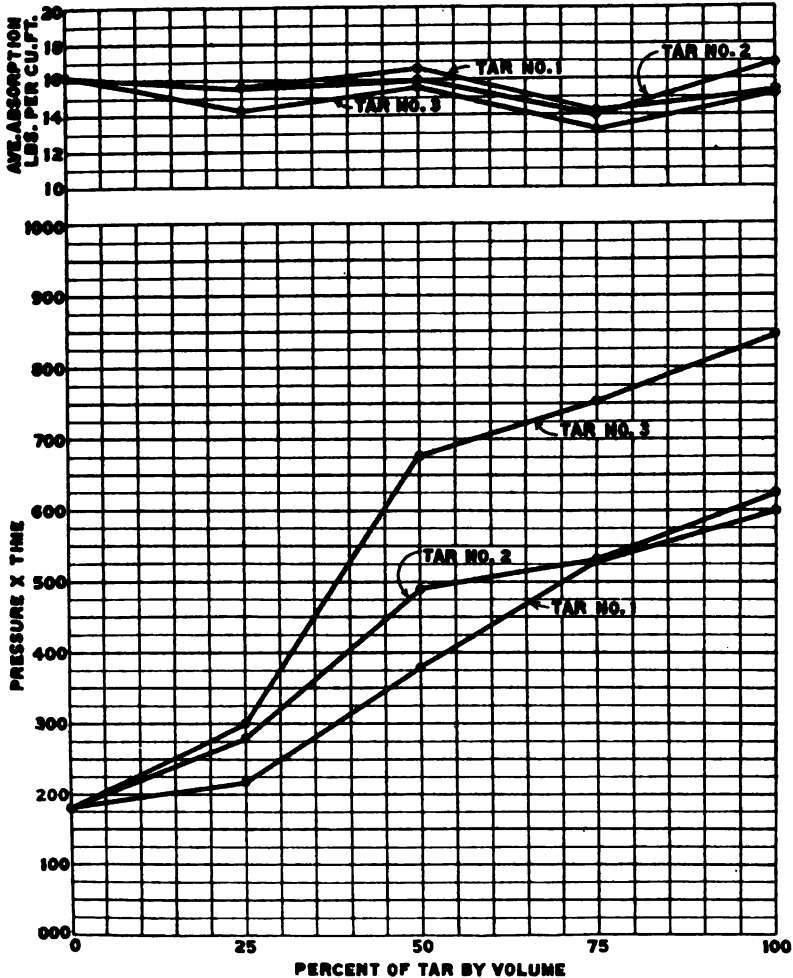


Figure 2.

Variation in time of treatment and pressure necessary to secure a given absorption in paving blocks using mixtures of creosote No. 4 and tars Nos. 1, 2 and 3. Temperature of preservative was 200° F. In all runs blocks were treated at 80 pounds pressure. If over 4 hours required, pressure was gradually raised to 150 pounds.

IMPRECGNATION TESTS

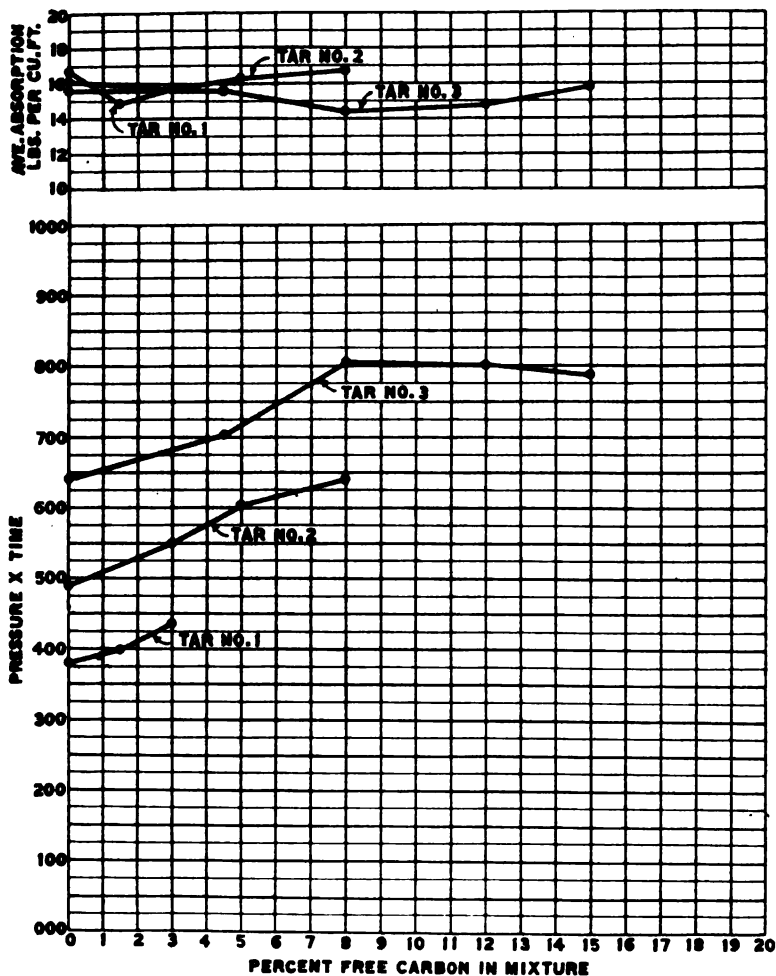


Figure 3.

Variation in time of treatment and pressure necessary to secure a given absorption in paving blocks using mixtures of creosote No. 4 and tars Nos. 1, 2 and 3. Temperature of preservative was 200° F. If over 4 hours required, pressure was gradually raised to 150 pounds.

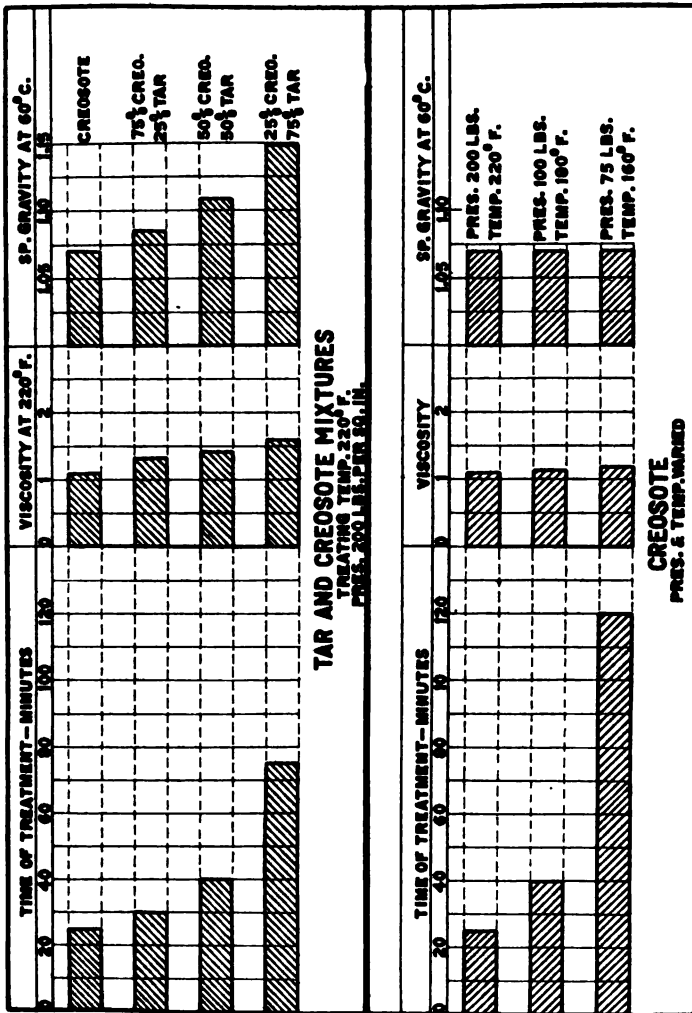


Figure 4.

Diagram showing the time of treatment required to secure a given absorption (16 pounds per cubic foot) in paving blocks using mixtures of creosote No. 4 and tar No. 5. Also the increase in time of treatment required to secure a given absorption of creosote when the pressure and temperature of preservative are lowered.

IMPREGNATION TESTS

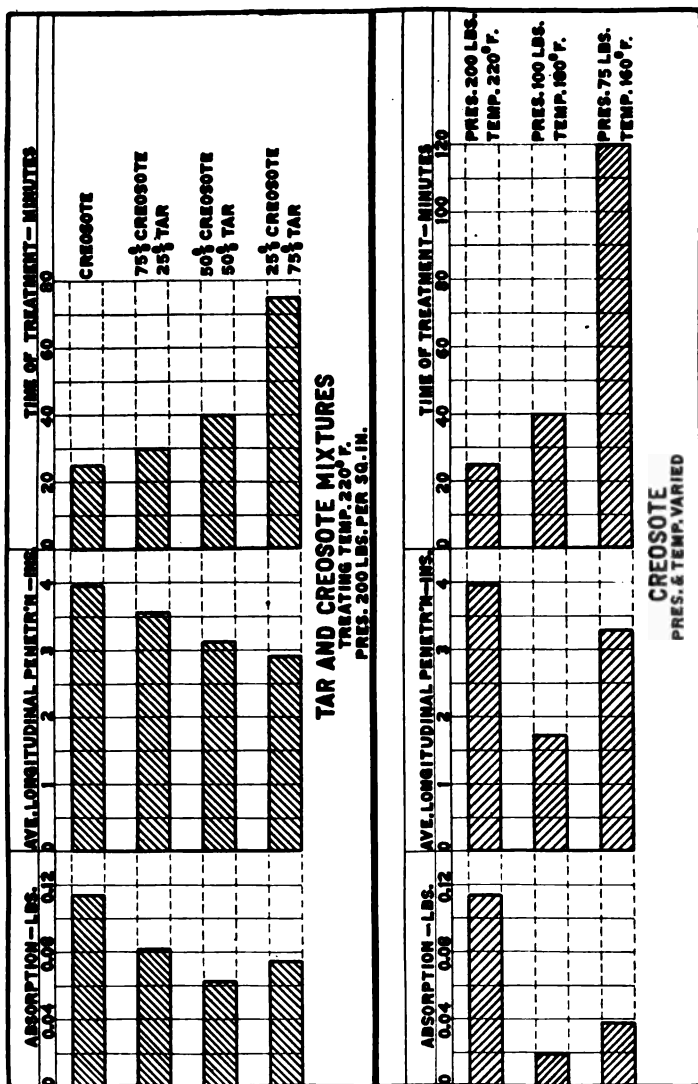


Figure 5.

Diagram showing the relation between absorption, penetration and time of treatment using mixtures of creosote No. 4 and tar No. 5. Also the comparative effect of varying the pressure and time of treatment.

PENETRANCE TESTS

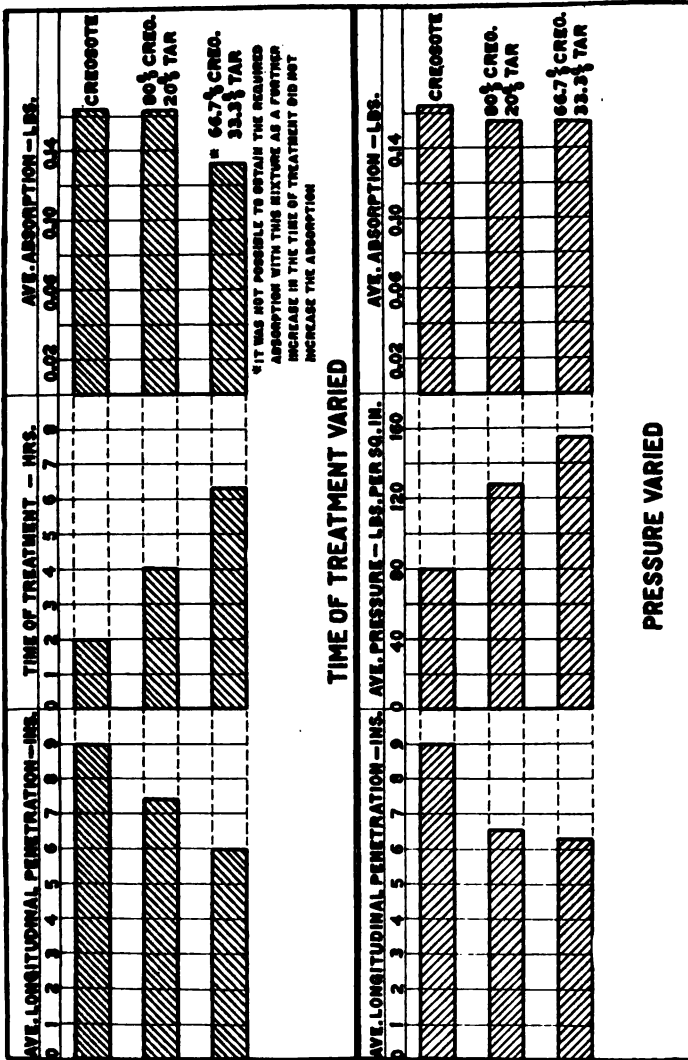


Figure 6.

Diagram showing relative effect of varying 1—time of treatment and 2—pressure, in order to secure approximately the same absorption in longleaf pine using mixtures of creosote No. 6 and tar No. 4. With time varied the treating temperature was 160° F. and the pressure 80 pounds per square inch. With pressure varied the time of treatment was 2 hours and the temperature 160° F.

PENETRANCE TESTS

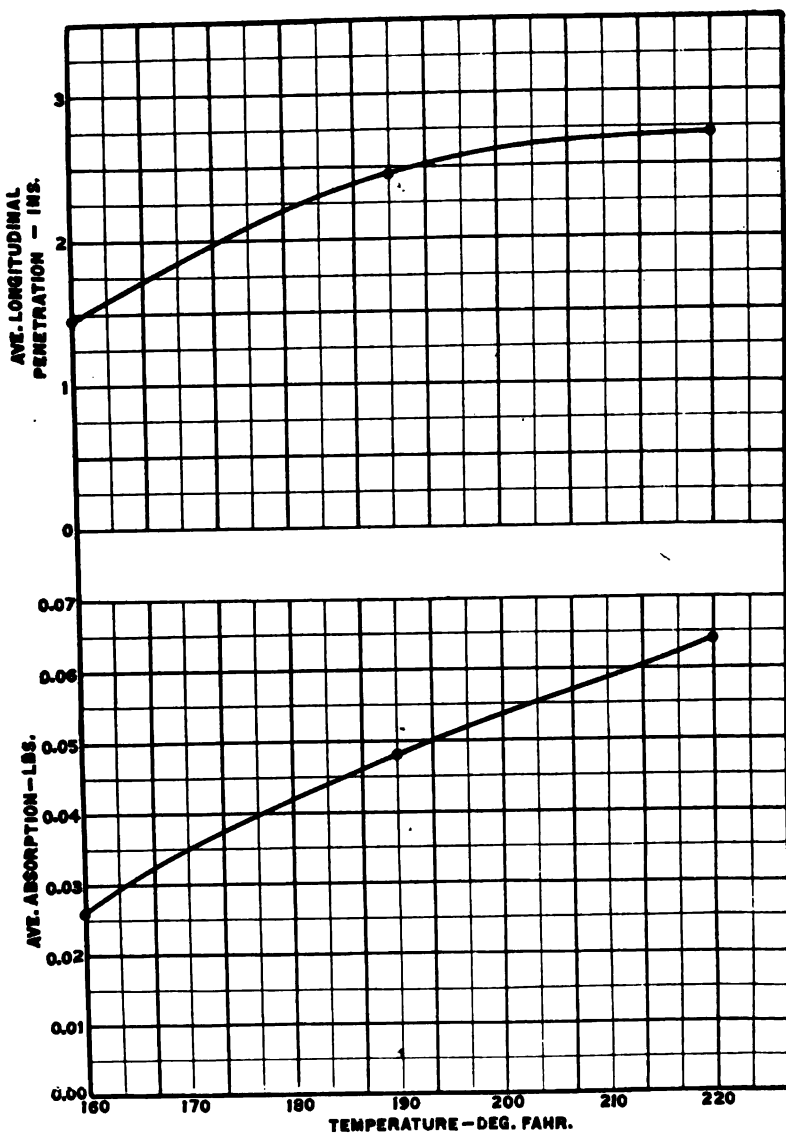


Figure 7.

Relation between absorptions and penetrations in longleaf pine using a mixture of 25% creosote No. 4 and 75% tar No. 5 at different treating temperatures. Pressure, 200 pounds per square inch; time of treatment, 1 hour.

CREOSOTED BLOCKS AND VERTICAL FIBER BRICK.

By E. A. Kingsley, Consulting Engineer, San Antonio, Tex.

In the central and south west for twenty years there has been a more or less extensive use of the yellow-pine block, impregnated with creosote oil, as a paving material.

During the last few years another block, this time a vitrified brick, has made its appearance, and has been very largely used. This material has been given the name vertical fiber brick, by the Western Paving Brick Manufacturers' Association, which association placed the brick on the market.

CREOSOTED BLOCKS.

The first blocks were laid in the central west early in the nineties. Before the 1904 Fair, St. Louis had built several block streets. Many cities followed and the pavement became a favorite. At first, the blocks were treated heavily and 20 pounds of oil was specified. The early streets were also laid with blocks 4 inches in depth and heart timber was specified. Long-leaf, yellow pine, heart specifications, 4-inch blocks and a 20-pound treatment meant a splendid pavement, but also a splendid cost.

Experiments continued looking for a method of cost reduction without a consequent quality reduction. Blocks were cut to 3½ inches and then to 3. Heart specifications were changed and the annular ring count was substituted. Then the quantity of oil was decreased to 18 and 16 pounds. These changes gradually brought the cost of the wood block pavements within the means of many cities which could not otherwise have afforded it, even for districts and streets where it was really desirable.

The early blocks were laid upon a concrete foundation, but upon a sand cushion and with a sand filler. Even yet many specifications call for this kind of construction. But the best modern practice has been to eliminate the sand filler and generally the sand cushion. A bituminous filler is now used in the best block streets and either



Mortar cushion, 1:3, mixed ready to spread on concrete base. In background cushion is spread and block laying is in progress.

a mortar cushion or a bituminous paint cushion on the smooth concrete is taking the place of the loose sand cushion.

In the writer's opinion, improper promotion and promotion methods have indirectly caused more block pavement failures than anything else. Wood-preserving concerns seemed so anxious to create a market for their block product that no attempt was made to urge the best methods of paving. Nor was any discrimination or judgment used as to the fitness of the street or district for a wood block street. Only two facts seemed to be borne in mind by the promoter. A street was advertised to be paved and his concern wanted to sell creosoted paving blocks. This condition resulted in uncalled-for competition with low-priced pavements. It also created a demand by the public for blocks in districts where blocks could not but fail. The public did not know but that blocks were good as a paving material anywhere and under all conditions. And the promoter kept the public in ignorance as long as possible.

Instances of this kind are in evidence all over the southwest. One particularly notable case was what was known as the "Water-

Cross-Streets District" in Little Rock, Arkansas. The total work amounted to about 50,000 sq. yds. Not a street in the district carried sufficient traffic to justify the use of blocks. Yet a large sum of money was spent thru promotion to secure the contract. The promoter advocated 3-inch blocks with a 16-pound treatment and the very cheapest methods of construction. The public was informed that contractors and engineers who opposed the use of blocks in the district were either ignorant or interested in some other form of paving. Over the protests of those who knew, the commissioners awarded the contract for blocks and the district was paved five years ago. More than half of the pavement has been entirely relaid in that time, under the contractors' guarantee. Thousands of yards have been relaid two and three times and the block manufacturers have been called upon to furnish many thousands of new blocks. And after all this expense, it is safe to say that there is scarcely a paved district in Little Rock in a worse condition than this district. This is but one isolated example. Numerous aggravating instances of the same kind may be found all over the southwest.

Probably the best constructed block pavements in the southwest may be found in the city of San Antonio. The climate is dry and the long hot summers are often followed by heavy rains or rainy periods. Clarence D. Pollock, as consulting engineer for the city, wrote the specifications and the San Antonio pavements have given no trouble from any cause. Generally they have been laid only on the heaviest traffic streets and in every instance a bituminous filler has been used. Both 3 and 3½-inch blocks have been used with equal success and 16 pounds of oil has been specified.

Particular care has been given to the construction of the pavements. This has as much to do with successful wood-block streets as the material entering into the construction. For the foundation the San Antonio specifications read, "Concrete foundation for brick or block pavements shall be finished to an absolutely true and smooth surface by floating after it has been placed." This insures a cushion uniform in depth.

No sand cushions have been used under the block pavements. A mortar of 4 parts sand to 1 part cement is mixed dry and spread to a depth of ½ inch. Just in advance of the laying, the newly-spread



Laying wood block pavement on East Houston Street, near Alamo Plaza, San Antonio, Tex.

cushion is well sprinkled by hand sprinklers. This sprinkling provides sufficient moisture to set the mortar. The blocks, however, are well rolled and bedded before the mortar cushion has taken its set.

The two photographs show first the workmen in the foreground spreading the mixed mortar cushion and in the background workmen laying blocks on the newly-made cushion. In the second picture the sprinkler man can be seen with his sprinkling pot. The darker or sprinkled section of the smooth cushion is very apparent.

After the blocks are laid, they are rolled to a smooth surface and filled with a bituminous filler. The pavement is gone over twice, and at the gutter, at car tracks, around manholes and other such places, sometimes three or four times. You will note in the third picture that the blocks are laid loosely so that there is plenty of filler to provide for expansion.

San Antonio has experienced practically no trouble due to expansion. Where a sand filler in other cities has been used, much trouble has occurred. And where blocks have been driven up tight, trouble has occurred.

The photo cuts made for the *Municipal Journal's* annual paving number, February 3, 1916, page 134, show very vividly the results of a lack of traffic on the block pavements. *Engineering News*, vol. No. 75, p. 696, illustrates the same condition. These photographs were taken in the same block less than 200 feet apart and the same condition of traffic and care existed.

Dr. Herman Von Schrenk, well known as an authority on creosoted blocks, states that San Antonio had secured as good results in block pavements as any city in the country, and yet only a few days ago, in conversation regarding pavements, the commissioner of streets stated that some of our recent block pavements should have been something else. The traffic was not sufficient to keep them in the best of shape.

The deductions made from a study and experience of nearly ten years with blocks, leads to three conclusions:

1st. Blocks may be treated successfully with either light or heavy oil and with not more than 16-pound treatment.

2nd. Blocks should be laid on a smooth concrete foundation, using not over a $\frac{1}{2}$ -inch mortar cushion; there will then be no settling due to unequal depth of cushion nor to movement of cushion.

3rd. Blocks should be laid loosely and then thoroly filled with a bituminous filler. The filler should be applied only when at a very high temperature and the blocks should be gone over at least twice with the filler application. All intersections should be well filled. No other than a bituminous filler should ever be used.

VERTICAL FIBER BRICK.

For many years Kansas has produced the finest quality of paving brick made west of the Mississippi River. In fact, the "Coffeyville Brick" had become the standard for paving material in the southwest. But with the Topeka decision came low-priced asphaltic concrete pavements and the middle west became a fertile field for such contractors. Brickmaking had become one of the big industries and asphaltic concrete paving became a hard competitor. The brick industry was badly hurt and the plant managers were forced



Applying pitch filler to well-oiled wood block pavement: Left to right, beginning with second man: Paving Engineer E. A. Kingsley, Mayor Brown, Dr. von Schrenk, Contractors Gowdy and Rushmore. In center, Commissioner C. H. Kearny.

to look for a method of decreasing the cost of brick to the paving contractor. The president of one of the big brick companies is responsible for the statement that asphaltic concrete competition was the hardest blow ever given the western brick industry.

After much experimenting, the western brickmakers placed on the market what they termed vertical fiber brick. Vertical fiber brick is vitrified the same as any other paver, but differs from the standard brick in that it is not repressed. It is a side-cut brick and when placed in the street is laid flat on the side with the grain of the brick vertical instead of being laid on one edge with the grain horizontal as is the standard paver. Presumably because the more or less rough wire-cut surface is exposed to traffic and is so apparent because the brick is non-repressed, the producers termed it "vertical fiber." Various theories have been given to explain the "fiber" and its value, but they are all theories. One so-called authority calls it "lamination understood." The writer transposing, has always "understood lamination" to be a detriment to good paving brick.

The standard vertical fiber brick is cut the ordinary length and width of the standard paver and 3 inches in depth. This, of course, reduces materially the number required to lay a square yard of pavement, consequently there is a big saving in freight. A considerable amount of material is saved in the manufacture and, as the brick are not repressed, quite a saving is also made in labor and machinery. Consequently they can be delivered on the street for a materially reduced price per square yard. But the cheapening process has not ended here. A $2\frac{1}{2}$ -inch brick was later produced and in instances it has been recommended and laid on a 4-inch concrete foundation. In fact, one "recommender" (he could hardly be called an authority) states that the ideal pavement would be a $2\frac{1}{2}$ -inch vertical fiber brick on a 2-inch reinforced concrete foundation. This man saves himself, however, with the statement that the only thing necessary to prove his contention is to find an engineer with the hardihood to stand by his convictions and lay this pavement. If any of you are looking for fame, this may be your chance. I would respectfully refer you, however, to our good friend, Mr. Blair, or to the chairman of our brick committee, Mr. Christ. Mr. Blair has forgotten more about good brick construction than most of us will ever know.

For more than a year the writer has been making a careful study of vertical fiber brick pavements in San Antonio. Twelve and one-half miles have been built, some of them now ending their third year. The major portion of the San Antonio yardage has been laid by Rushmore and Gowdy, contractors of ability, integrity and long years of experience.

Mr. Gowdy makes the following statement: "Vertical fiber brick, as laid by our firm in San Antonio, have held up under traffic conditions quite well and we are well pleased with their showing. For the ordinary small city and usual traffic conditions, or for semi-business or residence streets of the larger city, the 3-inch brick makes an ideal pavement. It must be well and carefully laid, however, and only on a first-class concrete foundation of not less than 5 inches. For the heavy traffic streets we do not believe the vertical fiber brick will compare in any way to the standard vitrified block and we would invariably recommend the standard block in preference to the vertical fiber excepting for the lighter traffic."

The writer's conclusions are similar to those of Mr. Gowdy, not only on his work but on work in other cities of Texas and Arkansas. Carefully laid, the pavement is smooth and very pretty in appearance. But the brick give a better chance for horses' shoes and iron tires to wear them on account of the vertical grain.

Most of the vertical fiber streets in the southwest have been laid with a bituminous filler. In only a few instances has a cement grout been used. About four years ago, at Helena, Ark., one street was laid by the writer, using cement grout. While this street does not carry an excessive traffic, it carries a moderate country traffic and has worn exceedingly well and smoothly.

Covering a period of four years' use of the brick, the writer would conclude that for moderate traffic where brick is desired, vertical fiber may be used with assurance of securing a first-class brick pavement at reasonable cost. Care must be had, however, in laying the pavement to secure the best results. The concrete foundation must be good and should be surfaced smooth. But where traffic is heavy, the additional cost of the standard block is worth more to the street than the few dollars paid over the cost of vertical fiber brick.

I am submitting herewith three samples of vertical fiber brick for the members of the Society to inspect. These brick are furnished for this occasion by the Thurber Brick Company of Texas and are the same as those used in the streets recently built in San Antonio.

REPORT OF COMMITTEE ON STANDARD TESTS FOR BITUMINOUS MATERIALS.

*Arthur H. Blanchard, Chairman, Columbia University,
New York City.*

Your Committee on "Standard Tests for Bituminous Materials" herewith respectfully submits its report covering its work during the preceding year.

During the past year your Committee has sent the following letter to chemists and testing engineers with the hope of securing the co-operation of all persons engaged in the testing of bituminous materials:

The Committee on "Standard Tests for Bituminous Materials" was appointed "to invite and direct the co-operation of all chemists dealing with bituminous materials for the purpose of further standardizing present methods of testing and for the purpose of encouraging and developing additional methods and appliances for valuating paving bitumens."

The Committee began its work by considering the essential properties of bituminous cements for bituminous macadam pavements (constructed by penetration methods), bituminous concrete pavements (constructed by mixing methods) and sheet asphalt pavements, and the tests which should be used to insure that bituminous cements possess such properties. As examples of essential properties, the following are mentioned: Non-susceptibility to changes in temperature; chemical stability thru long periods of time; cementitiousness. Methods for the following tests have been adopted by the American Society for Testing Materials or recommended by the Special Committee on "Materials for Road Construction" of the American Society of Civil Engineers: Specific gravity; flash point; solubility in carbon disulphide (CS_2); solubility of bitumen in carbon tetrachloride (CCl_4); solubility of bitumen in petroleum naphtha; viscosity; float; penetration; melting point; loss on evaporation; distillation; ductility; fixed carbon; paraffin.

The Committee earnestly requests that you assist it by sending to its Chairman a statement covering the essential physical and chemical properties which you consider should be covered in speci-

fications for bituminous cements to be used in the construction of the types of bituminous pavements previously mentioned, and also a statement relative to the tests in the above list and also new tests, which should be employed to insure that the bituminous cement possesses the essential properties which you propose, is uniform in character, and is manufactured under proper conditions. If you suggest the use of new tests or tests not in the above list, please submit methods for conducting such tests.

Hoping it will be practicable for you to co-operate with the Committee, we remain, with kindest regards and best wishes for continued success,

Sincerely yours,

COMMITTEE ON "STANDARD TESTS FOR BITUMINOUS MATERIALS."

A. H. BLANCHARD, *Chairman*.

Many replies have been received in response to the requests embodied in the above communication and the Committee wishes to take this occasion to publicly acknowledge its indebtedness to those who have cordially co-operated in its work.

The Committee herewith submits, for the consideration of the members of the Society, the following conclusions:

It is the judgment of the Committee, based on present knowledge, that the inclusion of the paraffin determination in paving specifications serves no useful purpose.

The Committee believes that specifications for bituminous cements for paving purposes should cover the following properties:

(1) Proper consistency;

Determined by penetration, melting point, float or viscosity test, or other test to be devised.

(2) Proper binding quality;

(No agreement has been reached by the Committee as to tests which fully determine this property.)

(3) Stability, including retention of physical and chemical properties;

For asphalts, determined by loss on heating and consistency of residue, or other tests to be devised.

For tars, determined by distillation test and consistency of residue, or other tests to be devised.

The Committee believes that when the bituminous cement is combined with the mineral aggregate, the mixture should possess (a) toughness; (b) resistance to abrasion; (c) malleability; (d) stability; and that tests should be devised covering the measure of each property.

It is recognized that the tests enumerated do not fully cover the properties mentioned above. The Committee hopes to elaborate existing tests and devise new ones and invites the co-operation of the members of this Society to that end.

Respectfully submitted,

ARTHUR H. BLANCHARD, *Chairman*,
PREVOST HUBBARD,
FELIX KLEEGER,
FRANCIS P. SMITH,
LESTER KIRSCHBRAUN.

THE RESURFACING OF OLD BRICK PAVEMENTS WITH SHEET ASPHALT AT COLUMBUS, OHIO.

By Thomas H. Brannan, Superintendent of Asphalt.

The resurfacing of old brick or block streets with asphalt is a subject that seems to be demanding the attention of municipal engineers thruout the country. We have a good many callers and receive numerous letters from other cities in regard to this type of pavement. Property owners and public officials in some cases are insistent upon this form of construction and it therefore behooves the city engineer to be ready to adopt this type of pavement, or be able to convince those interested that it is not the thing to do.

At Columbus, Ohio, there is being laid, on the average, about 150,000 sq. yds. of sheet asphalt a year. By far the largest per cent. of this yardage has been laid on new concrete foundation and on streets that have never been paved before. We have, however, a large number of old brick pavements that are worn out and some of these we have resurfaced over the brick.

It is not my intention either to promote or discourage the resurfacing of brick streets with asphalt, but merely to describe the method used at Columbus, Ohio, and point out some of the advantages and disadvantages of this kind of construction.

About thirty years ago the city of Columbus began to do a considerable amount of brick paving. Prior to that time cobble stone had been used on a number of streets.

Three of the old cobble stone pavements were resurfaced with asphalt about twenty-eight years ago and they are still being maintained. Two of them should have been resurfaced not later than the twentieth year, but the third (Bryden Road, Parsons avenue to Twenty-second street) is still in fair condition and with a reasonable amount of maintenance it can be kept in repair for several more years. Another old cobble stone pavement resurfaced fifteen years ago (Washington avenue, Broad street to Town street) is in excellent condition today. It has not had any repair and shows no signs of cracking or disintegration. The service which these



Sheet asphalt surfacing over old brick pavement on Sixth Street, Columbus, O., 1½-inch binder and 1½-inch top, 1912.

streets have given probably accounts for the fact that it was decided about four years ago to try resurfacing some of our old brick pavements.

These old brick pavements were laid on a gravel, a crushed stone or a creosoted plank and sand foundation. The brick were small size red brick and the joints were either tar or sand filled.

In 1912 three of these old streets having an area of about 14,000 sq. yds. were surfaced over with sheet asphalt. Since that time nine other similar streets have been given the same treatment and the total yardage has been increased to about 75,000 sq. yds.

One of the first questions to be considered in resurfacing brick with asphalt is that of surface drainage. All of our old streets were laid with a 6-inch gutter. After a 3-inch coat of binder and top has been put over the old brick, it therefore leaves a very shallow gutter. On streets having a lateral grade of 0.6 per cent. or over this is not so serious, but for grades less than 0.6 per cent. a 3-inch



Resurfacing old granite block pavement with asphalt on Twentieth Street, north of Mt. Vernon Street, Columbus, O., 1915.

gutter may not be deep enough to carry the water. On these streets one of two things can be done, viz:

The first method is to take up the old brick in the gutters for a width of 3 to 4 feet from the curb and lay a concrete base to such a grade that when the gutter is paved with new brick these brick will be high enough at the outer edge to form a shoulder for the edge of the asphalt and be 6 inches below the curb at the gutter line.

The second method is to take up the old brick for a distance of 3 to 4 feet from the curb, then concrete this space, leaving it low enough along the curb to lay asphalt and still maintain a desired depth of gutter. The outer edge of the concrete can be brought to the level of the old brick and an asphalt roadway can then be laid from curb to curb. This will increase the transverse grade or crown of the street near the curb, but not enough to be seriously objectionable.

Before any asphalt is laid on old brick it is essential that the

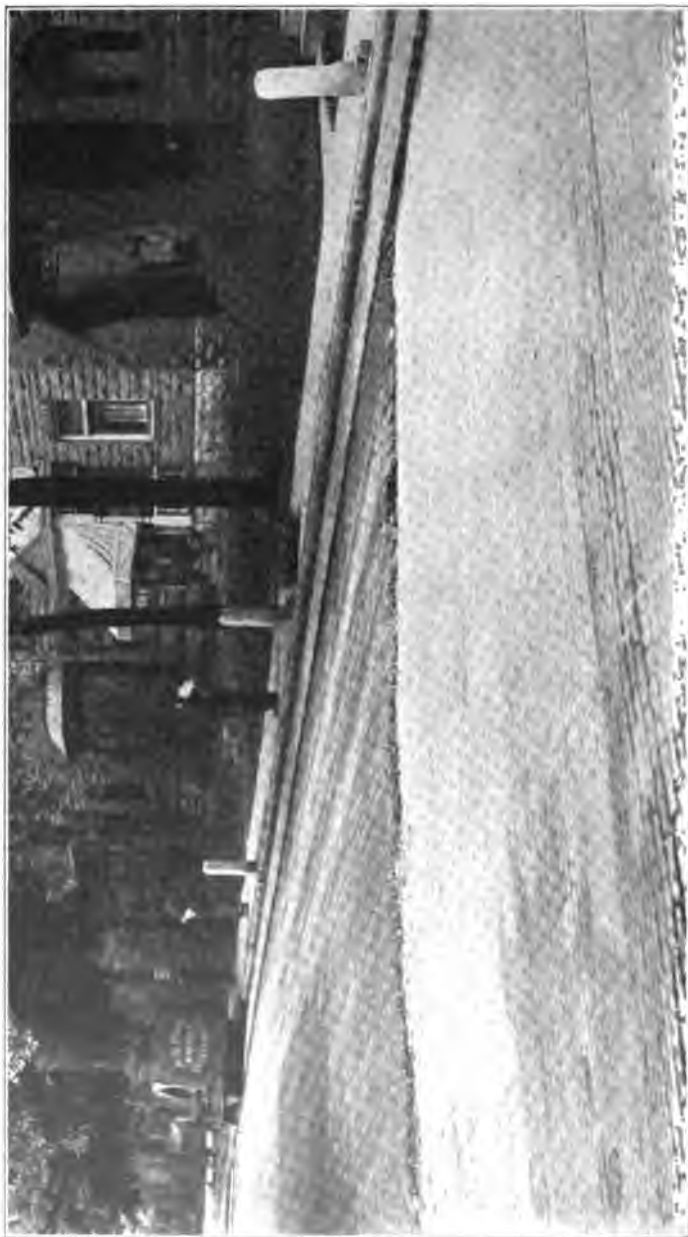
old brick pavement be cleaned and all of the dirt removed from the joints to a depth of at least $\frac{1}{2}$ inch. This is done most effectively by flushing with a fire hose. It can also be done by raking out the joints with sharp pointed picks, or hooks, and then sweeping. If flushed, it is necessary to give the street some time to dry out and for this reason the sweeping is preferable during the late fall months.

In case the old brick are worn thru at any point or are more than 3 inches below the general grade, these holes or depressions are cleaned out and concreted. At intersecting streets it is necessary to either go back of the property line a few feet and relay the brick, bringing them up enough to form a shoulder for the asphalt at the lot line, or to take up the brick in the wing and let the new asphalt pavement down enough to meet the existing pavement on the cross street.

A closed binder containing from 20 to 25 per cent. of material passing a 10-mesh sieve is preferable to a paint coat. A paint coat of asphalt must be cut back with naphtha in order to apply it and unless this naphtha entirely evaporates before the top is laid it is likely to work up thru the top and be detrimental to the pavement. The large variation in the thickness of the top, however, would be the greatest objection to the paint coat. The wide-tread roller, bearing on the different depths of top, will compress the thinnest portion the most and leave the deep spots only partially compressed. Trucks going over the pavement after it is completed will further compress the deep spots and form depressions in the pavement. The depressions thus formed will likely produce shoving and destroy the pavement.

We use $1\frac{1}{2}$ -inch top and $1\frac{1}{2}$ -inch binder on these streets. The $1\frac{1}{2}$ -inch binder is figured on the basis of 1 cu. yd., box measurement, laying 20 sq. yds. Whatever excess there is over this amount is paid for by the cu. yd. as extra binder.

Where the brick foundation is very irregular the binder is laid in two courses. The depressions are first filled and rolled and then the $1\frac{1}{2}$ -inch binder is laid. An examination of the under side of a slab of binder taken from a cut on a resurface job of this character showed the print of all the brick and also showed the binder driven in between the brick sufficiently to give a good bond.



Resurfacing old brick pavement with asphalt, using $1\frac{1}{2}$ -inch binder coat and $1\frac{1}{2}$ -inch wearing surface coat. New brick gutters with asphalt laid between them. Bryden Road, between Ohlo and Miller Streets, Columbus, Ohio, 1915.

The average amount of binder required on all the streets that have been laid was .022 of a cu. yd. per sq. yd. of top. This at \$7.00 a cu. yd. would be an item of about 15 cents a sq. yd. for extra binder. This amount plus 5 cents a sq. yd. for cleaning deducted from the cost of excavation and new concrete, represents the saving that can be made on this kind of construction.

In our city with concrete figured at 70 cents a sq. yd. and excavation at 95 cents a cu. yd., this saving would amount to 75 cents a sq. yd. of finished pavement. This saving compounded annually at 4 per cent. would amount to \$1.35 a sq. yd. at the end of fifteen years, or enough to almost renew the pavement.

Another advantage of this form of construction lies in the fact that it is not necessary to have a street torn up nearly so long for repair and, if required, it need not be closed to traffic at all except on the day that asphalt is being laid on a certain portion of the street.

As a general proposition I would not advise attempting to surface over the old brick on a street having a car track. The only way that this can be done, if the brick are left in, is to raise the track, and this causes a bad condition with regard to the grade of the tracks at all intersecting car lines.

I did take up the brick in one block in Columbus and by using about 3 inches of binder and 2 inches of top surfaced over the old macadam foundation.

This was laid on a downtown street. The work was done by the city plant four years ago and the street is in very good condition to date. In that case it was quite an advantage to have the street torn up only a few days.

Three of the streets that were resurfaced four years ago are within four blocks of the center of the city. I cannot see but what they are in as good condition today as if they had been laid on a new concrete foundation. They are not cracked. They have not shodded and they have not had and do not need any repair. One of them took an extraordinary amount of traffic last year when the parallel streets on each side of it were in bad condition.

The nine streets resurfaced since 1912 carry a somewhat lighter



Resurfacing old brick pavement with asphalt, using binder coat and wearing surface coat. Asphalt laid from curb to curb. Gay Street, between High and Fifth Streets, Columbus, Ohio, 1912.

traffic than the 1912 streets and would all be classed as residence streets. They are all in good condition and have not had any repair.

We have not laid any surface using a paint coat instead of a binder, nor have we laid any asphaltic concrete. It would not require so great a depth of material to bring the street to grade if an asphaltic concrete were used, and consequently this construction would be less expensive.

In conclusion, I would say that wherever it is possible I would prefer to resurface over an old brick street from curb to curb if the longitudinal grade will permit. I find that less extra binder is required for this construction than where new brick gutters are laid.

In general, our brick streets resurfaced with sheet asphalt are satisfactory and the thing we are interested in now is how to get equally good results with less money.

BRICK STREETS RESURFACED WITH ASPHALT, COLUMBUS, OHIO.

Streets	Width	Completed	Thickness	Sq. Yds. Asphalt	Price Per Sq. Yd.	Extra Binder Per Sq. Yd. Top	Cost of Extra Binder Per Sq. Yd. Top	Total Cost Incl. Extra Binder
Gay St., High St. to 5th St.	46.5	11-1912	2" -1"	7218	\$0.92	\$0.043	\$0.05	\$0.97
Fifth St., Long to Broad St.	30	11-1912	1½"-1½"	2577	1.22	.005	.03	1.25
Sixth St., Broad to Town St.	30	11-1912	1½"-1½"	3979	1.25	.0127	.09	1.34
Wilson Ave., Broad to Bryden.	30	7-1914	1½"-1½"	5037	1.37	.0313	.22	1.59
Monroe Ave., Broad to Oak.	30	9-1913	1½"-1½"	1274	1.40	.0301	.21	1.61
Grant Ave., Broad to Naghten.	32	9-1915	1½"-1½"	4793	1.36	.0261	.18	1.54
Eighteenth St., Long to Mt. Vernon.	30	8-1915	1½"-1½"	3264	1.35	.0207	.13	1.48
Twentieth St., Broad to P. C. C. & St. L.	30	8-1915	1½"-1½"	10716	1.36	.0366	.25	1.61
Bryden Rd., Ohio to Miller.	40	7-1915	1½"-1½"	10066	1.36	.0201	.13	1.49
Tenth Ave., High to Neil.	30	8-1915	1½"-1½"	7289	1.34	.0118	.08	1.42
Fifteenth Ave., High to Indianola.	30	8-1915	1½"-1½"	3943	1.36	.0154	.11	1.47
Dennison Ave., Buttles to Fifth.	30	1916	1½"-1½"	13720	1.39	.0371	.26	1.65
				<u>73876</u>				

LACK OF ATTENTION TO DETAIL THE GREATEST SHORTCOMING OF AMERICAN MUNICIPAL WORK.

By Henry Welles Durham, County Engineer, Hackensack, N. J.

It is a frequently uttered platitude that good maintenance is as necessary as proper original construction. It seems to be less generally recognized that lack of attention to minor details in both construction and maintenance is responsible for more of the poor conditions existing in our public work than is any lack of knowledge of correct principles.

By many, the belief seems to be held that attention to maintenance means merely the giving to the construction to be maintained an annual overhauling, and this brings us to a fundamental difference in practice and basic belief between our country and the older ones of Europe; namely, that it is better, or less trouble at least, to use any piece of machinery, or engineering structure, to the limit of its capacity before spending any money on repairs; a limit which frequently is the limit of its life, after which the structure is scrapped and a new one substituted, rather than, by careful detailed maintenance, to prolong its life indefinitely. Such policy is sound in a pioneer state of civilization. In the present age, and particularly in reference to our municipal affairs, we have now attained a condition of permanence comparable to the status of the older countries, and it is time for us to abandon pioneer methods and consider the adoption of a habit of thinking which will take for granted the necessity of maintaining municipal works constantly in a condition as near perfect as possible.

All the careful study which has been given in recent years to the bettering of our methods of highway construction, will be of little value if we continue to neglect that careful attention to the minor details of their design and construction which goes beyond the general field and concerns itself with particular matters, too frequently left to the attention of careless subordinates, and if we fail to acquire for our departments charged with maintenance work the adoption of a habit of maintenance which will take for granted the

necessity of keeping the plant to be maintained in a constant state of repairs, and will not regard, with complacency, a good explanation as having equal value with a satisfactory result.

In no other country in the world has there been given so much attention to the production of improved specifications, with the result that we have today probably as scientific designs with fewer unknown or debatable questions than can be found in the practice of foreign countries. By many the belief is held that the continuance of the studies embodied in the proceedings of this and similar associations, will result eventually in absolutely standardized specifications. Admirable as is the work done in many quarters in this regard, such can not be the case until there is reached an end of human progress. It has seemed, to the writer, desirable, without in any way detracting from the work of those engaged in the scientific improvement of specifications, to point immediately to the fact which has been frequently noted that we are too liable to rest contented with our written prescriptions without seeing whether they are supplemented in practice by the necessary detailed local construction to attain the best results; nor whether, after the original construction has been finished and interest transferred to some other new work, there is given any continuous attention to maintaining the results in anything like their original state.

There is much talk in these days of military preparedness, and a large part of it contains the same fallacy peculiar to our civil mental state. Our congress and public demand the construction of a large navy. They are not interested in the fact that we have not sufficient equipment or men or ammunition for that at present existing. More coast defenses are required. Little notice is taken of the fact that we had to strip our existing forts of their troops to provide additional protection for our southern border. The recent mobilization of the National Guard showed that, while it was possible to provide vacationists at Plattsburg with new rifles and equipment, there were not sufficient weapons or uniforms available to supply the soldiers ordered-out for possible warfare within a period of three weeks. The wonderful efficiency displayed by European armies consists not only in their size and manifold strength of equipment, but principally in the attention which has been devoted to working out the minor detailed problems, such as providing each

soldier with proper and sufficient footwear, and the planning, years in advance, of seemingly minor details of military transportation.

A comparison of our municipalities with those of Europe brings out our shortcomings, as contrasted with our brilliant promises, very clearly. There is nowhere in Europe a better pavement of any type than our best, and the same claim would apply to other lines of municipal improvements, such as water works and sewers. There are few foreign cities having as large a proportion of modern improved street surfaces as exists in many of ours. On the other hand, there can seldom be found a European city whose average street condition is as poor as ours; nor whose worst is nearly as bad. If this country is to compete on equal terms in the future with the older countries of the world, it will be necessary for us to adopt a national habit of orderliness comparable to theirs, which is, in a great respect, responsible for their points of superiority.

It is recognized that for comprehensive planning of all municipal work, the engineer must have responsibility and security in tenure of office; otherwise he is merely a rubber stamp to give an air of pseudo-science to the plans of political department heads and to be superseded at any change of administration when places are wanted for favorites or relatives. It is equally true that such responsibility and continuity of office are requisite to provide attention to detail and the adoption of standard types of construction. It seems to the writer that municipal engineers, while today more alive than formerly to their duty as citizens of arousing public attention to the necessity of improving their status as public servants, are still behind in paying attention to the greatest possible extent under present conditions to the minor details under their direction.

For specific instances, let us take the highway engineer and his work in certain directions.

First, the details in the planning of a road or street, either for original construction or reconstruction. In our country, as compared with Europe, we seldom see any definite rule or purpose in the choice of width of paved surface. Too often it is decided by boards of aldermen or road committees. The relation of sidewalk to carriageway width is usually a haphazard choice. Too often the municipal engineer neglects the opportunity to go on record with a defi-

nite reason for these dimensions and a rule to govern all future work. Under all roads, country or city, excavations are made from time to time and public utilities placed therein. Abroad, in many countries, there are standard rules to govern this work which must be followed in all such construction. With us, it is usually a question of the use by the corporation of all available arguments to get what it wants in each special case without any reference to the community's best interest and with little control by the engineer. Some foreign communities go so far as to have precise plans for all types of streets and roads, showing what is to be the location of all obstructions, even to the shade trees.

Our greatest neglect of detail and most wasteful policy is frequently found in the construction of a street in a new district. Abroad, in the best controlled regions, no street can be permanently surfaced until its type of development is known. All public utilities required for the districts in question must be installed, including all necessary connections to property lines, before any pavement construction is started. After all this is done, the road is finally surfaced with a type of pavement, including curb and sidewalks, in accordance with the traffic conditions to be anticipated. The result is that the work once completed remains so, and does not require to be repaired in a short time on account of excavations not anticipated; nor does it require to be changed to meet a different class of development. The same state of permanency prevails in what is regarded with us as other minor details; such as provisions for surface drainage, the most suitable type of curb and proper design of intersections. Choice of curb with us is too frequently made as a result of the relative local strength of those making various patented designs of concrete reinforcing, or the union engaged in the dressing of local classes of stone. For example, in New York city, altho granite makes the most economical and enduring curb for most of its streets, bluestone is largely employed on account of the strength of the Bluestone Cutters' Union. The writer was requested, by an elected official, to change one of his annual reports condemning bluestone curb, on account of the political influence exercised by that industry.

Another case can be cited in the vicinity of New York where a county road which forms a political boundary is being jointly resurfaced by two counties. The sidewalks and curbing are being

taken care of by the local municipal authorities. On one side of the road, the village engineer has a preference for concrete curbing and is so constructing it. On the opposite side, but in another town, local influences have secured the use of bluestone.

Hardly any two adjacent communities can be found with similar standards as to storm water inlets. Some prefer catch basins with granite heads, others use any one of various patented types of cast iron inlets. In some places these are located at the corners of intersections; in others, away from the corner at the sides; and hardly ever has the engineer any definitely adopted policy. European engineers realize that a low curb height is an advantage; that gutters should not be used as canals, and, consequently, they place their storm water inlets away from corners where the public most frequently crosses and have them at frequent intervals to avoid large streams of running water. New York city, in its five boros, has five different sources of authority in regard to these points; all thinking differently. The result is general confusion and frequent change and no very definite policy in any one boro. An engineer who properly appreciated the importance of attention to this detail, minor only in that it is so usually neglected, would plan a procedure in close co-operation with the sewer design and adopt a standard form of construction which could be followed without making a special study of each individual street.

The greatest confusion is seen in our lack of any ideas as to proper design of street intersections. This applies equally to state or county roads as to those of cities and towns; the former may at any time in the future become the latter, and while it would not be a good policy to introduce into their construction expensive improvements that might not be needed for many years, they should be so laid out that these improvements could be added and become an integral part of their plans at any future time. At present, a suburban development usually requires a complete reconstruction of the surface drainage provisions previously adopted for a country road. Grades at intersections should be so planned that the intersection proper is level, avoiding the meeting of complicated slopes, and the curb radius of corner turns should be made equal to the sidewalk width of the narrower street to allow the greatest ease in turning out from one street to another, coincident with the preser-

vation of the standard sidewalk width. This is seldom done. The result is that we have protruding points of sidewalks hampering wheeled traffic without any additional convenience to pedestrians, and square corners with catch basins at the apex, concentrating storm water at points most desirable to be dry to facilitate crossing.

Catch-basin design receives little attention. Where it is necessary to provide against the carrying into sewers of large amounts of gutter debris, the use of a settling pool in the basin is probably necessary. It can be avoided, however, in many cases, if sufficient inlets are provided to avoid a large gutter flow in stormy weather and if storm sewers have sufficient grade to carry away minor collections of debris. From a sanitary standpoint, these pools of stagnant water in catch basins are indefensible. They constitute a menace to health and it will be found frequently that the cost of cleaning sewers directly is less than the necessity of cleaning an extensive series of basins at frequent intervals. If the latter is not done, the basins lose all possible value.

Again, too little attention, and frequently none, is given by the municipal engineer to the design of such minor bits of construction as manhole heads and covers, street hydrants, and curb posts for lamps and other purposes, and no thought at all is given to their orderly position. Usually, each public service authority or corporation designs its own structures of this class, or adopts standard commercial designs. The result, as may be seen in any of our great cities, is the use of manhole covers of many types; some of them difficult to adjust to the adopted pavement and few of them possessing the best surface for traffic, or approximating in any way the relative smoothness of the pavement. The engineer should decide and adopt a definite rule as to what of these public utilities can be placed under sidewalks, where excavation will work less hardships in the roadway; as to where manholes can be placed to occasion least annoyance to traffic, and what design of head will conform best to the pavement. The sidewalk posts, of whatever character, should have prescribed positions and be placed according to rule. In many foreign cities, it is found possible to reduce the number of such obstructions by placing hydrants in recesses below the sidewalk level under covers flush with the surface with their location definitely referenced by marker plates on adjacent buildings, and such a pro-

cedure has been found possible in at least one of our great cities. On many sidewalks in New York, pedestrian traffic is forced into the roadway to get around the confusing mass of hydrants and lamp posts. Even such a small question as the suitable design of street name signs is not beneath the careful study of the engineering office charged with municipal work, but it seldom receives attention from any but temporary reform committees. In all these matters, we are definitely behind European practice, and only by recognizing this fact can we attain possibilities of improvement.

But, after we have completed our municipal improvement, of whatever nature it may be, we have only attacked the first phase of our problem. It would seem as if design and construction were regarded by most Americans as the sole end of the municipal engineer, and that maintenance is a trivial problem which can be turned over to any political superintendent. This thought was, of course, largely due to the fact that, in pioneer communities, it has very generally been the duty of the municipal engineer to design and construct new works whose maintenance was subsequently under control of others. New construction work being in our country largely carried on by contract, has not offered so great opportunities for political appointments, as has maintenance carried on by city forces, with the resulting possibilities of filling places for political effect. Our most advanced municipalities are learning that they must get beyond this stage and approximate to the European practice of placing under their municipal engineer complete control of whatever construction activities he may have been charged with. With his increased responsibility, it is time for him to cease a merely perfunctory execution of them so frequently found in municipal forces and to devote some thought to the attaining of a maintenance organization which will work with an efficiency comparable to that found in the usual municipality of England, France and Germany.

It is unnecessary to attempt to do more than indicate anew the direction in which maintenance methods fail; namely, that we are addicted to sporadic intermittent repairs on a large scale instead of by constant application to small matters keeping our public works in a uniform condition of excellence. We appropriate annually for the construction of roads and streets sums which are re-

garded as enormous by all European communities. We produce results which call for unqualified admiration, but we lose interest when the new work is done and expect it to take care of itself, and when its deteriorated condition becomes a cause of public complaint, we repeat the process with a large and new appropriation for repairs. The contrast is most strikingly brought out by two incidents recently noted.

On a London street, whose paved surface was ten years old, and whose guarantee contract was about to expire (coincident with the expiration of the loan period, for which the money had been raised to do the work) there was a small party of laborers at work, in the employ of the contractor, engaged in removing individual defective blocks and replacing them with new ones, preserving up to the moment when the street was reconstructed with a new pavement a surface that, to American eyes, looked almost perfect. In one of our Atlantic seaboard cities can be seen today an intersection of two streets, one improved four years ago, with one of the most modern types of pavement for heavy traffic, the other having a surface completed within the past year. Lack of attention to a definite preliminary plan, however, made it necessary, when the second pavement was constructed, to relay a large part of the intersection to meet the different plans which a change of administration in control of the streets had brought about, and now, some months after the work has been done, two manhole heads remain in the intersection with surfaces some inches below the new pavement which heavy traffic has already begun to break down to meet the lower level of their iron covers.

In another case, lack of attention to the regulation of street traffic has permitted the use of motor tractors and trailers in connection with heavy excavation work, of a type and at a speed which has developed many defects in one of the most expensive and durable classes of pavement, and these defects, instead of receiving constant attention, were allowed to develop for months, producing ruts which could have been avoided by following the European method of persistent minor repairs. Such instances could be multiplied indefinitely and will occur to the recollection of all engineers engaged on public work. The writer regrets that the brief space of a furlough from the Mexican border has prevented a more careful treatment

of his subject and a more detailed illustration from the many examples available on his records of the contrast between the orderliness of European municipal and highway work and our disjointed policy. His present opportunity has given him, at considerable cost, a personal view of the results of a lack of preliminary preparation and subsequent plan for the details of the maintenance of an international boundary, even to the absence of those primary requisites—highways. Is it too much to hope that an age which is slowly realizing that political rights must be maintained by something more powerful than good intentions, will cease to try to keep their roads paved with such means at least until they learn their destination in the next life?

MAINTENANCE, AND ITS IMPORTANCE IN SELECTING PAVEMENTS.

By C. D. Pollock, Consulting Engineer, New York City.

Investigation shows that very few of our cities, counties or states give any real consideration to the maintenance costs in deciding upon proper pavements for streets and roads. Even a cursory examination of the various reports shows this matter to be greatly neglected. Many cities have appropriations for repairs. These appropriations are always used, but the reports do not show the actual conditions as to whether the various streets were kept in good repair, or whether the money was simply spent and holes were fixed as far as the money would go, and the rest were left to be done with another year's funds. Unless these facts are known, it is impossible to compare maintenance costs and arrive at any true result.

Many of our cities possess experienced engineers to draw specifications for, and to supervise the construction of new pavements, and they get good pavements of their kind, but the authorities think that the work of the engineer is done when this has been accomplished. In other words, the idea seems to prevail that when a pavement is laid, the engineer is thru and that any politician with a good following can do the rest. As a result the maintenance work and the replacing of pavement over corporation and plumbers' cuts are very often under a man who is known as superintendent of streets, or of repairs, or has some similar title, and whose only qualification is that he was a good worker in the last campaign. He may do the best that he can, and then again he may only see that a maximum number of voters are given employment in making alleged repairs to the pavements. Such a man will probably keep track of the cost of repairs by weeks, months or years, but will have no idea of keeping costs by streets, blocks, or contracts, and as a consequence his costs will mean nothing to him or anybody else, except that he has had an appropriation and has spent it where he thinks it will do the most good at the next election.

By this method the engineer who laid the original pavements will

have gained no knowledge as to the real costs of his pavements, and consequently, will be in no better position to judge whether he should continue to lay the same kinds of pavements under similar traffic conditions, or whether he should select more durable materials for those conditions. The best that he can do is to judge by casual observation, which in the case of most busy municipal engineers can be of the most general character at best.

The above seems to be the rule rather than the exception in this country, and applies not only to municipalities, but also to our county and state highways as well. Some of the State Highway reports of neighboring states furnish a great amount of data to illustrate this point if one takes the trouble to dig it out, but the work is so divided and the reports are from so many different officials, that nothing can be learned without a large amount of labor.

One near-by state which continues to lay mainly water-bound macadam, even upon main arteries of travel, shows in its report, or rather it does not show, but by spending considerable time in the study of the various sections of the report it was found that with the first cost of the macadam and the repairs to this in a period of six years, the total cost per square yard was considerably more than would have been the cost of laying the same width of granite block pavement on a concrete foundation in the first place and making the additional provision for the sinking fund. At the end of the six years the reports gave the condition of the roads as bad, even with the large sums spent in repairs. This was applicable to some thirty or more of the main traveled roads between important towns and cities. This search could be carried further, to include many more roads where a cheaper form of pavement, yet a more substantial one than water-bound macadam, could have been used, with much economy from the standpoint of maintenance.

The remedy for this condition is to continue to employ experienced paving engineers on the original construction of the pavements and then put the maintenance under the same engineer. If this is done, the engineer will watch his pavements carefully, also his maintenance costs, and will observe when he requires a more substantial form of pavement under certain traffic conditions, and also when he has the proper pavement for those conditions. In other words, he will keep careful account of the cost of maintenance

of the various pavements, together with the traffic each bears, and then he will be in a position to make his deductions as to when to use this kind of pavement and when to use another kind. With the present method of divided responsibility, as prevails in so many of our cities, this is impossible.

The all important point is to place the new construction and the maintenance under one engineering head and then hold him responsible for results, and if he is given the authority, he will get results far superior to those now obtaining.

DISCUSSION.

MR. KEMPER: May I ask Mr. Pollock what provision is made in New York City for the resurfacing of asphalt streets as to assessing the charge for it?

MR. POLLOCK: In New York City all repaving work is paid for by the city at large, but that is not generally the case in many other cities of the state. In New York City the original improvement is paid for wholly by the abutting property, and after that it is a charge on the city at large. Until recently all repaving was paid for by 50-year corporate stock, so that there were a number of repavings before the first one was paid for by the retirement of the 50-year corporate stock. But this has been changed and New York is adopting the pay-as-you-go policy. This change has been made on the installment plan and in 1917 or 1918 the entire repaving fund will come from the tax budget.

MR. KEMPER: Do you know what concrete base they use under asphalt in New York City?

MR. POLLOCK: On all first-class pavements, 6 inches of 1:3:6 mix. In some of the outlying streets in suburban work they put down what they call a preliminary pavement on 5-inch base, and later, when they put in a heavier construction, they assess the difference in cost between the original and the heavier construction.

MR. KEMPER: And they reconstruct a thicker base?

MR. POLLOCK: Of course. In some localities that first base will do for a great many years.

THE FUNDAMENTAL NECESSITIES IN THE MAINTENANCE AND UPKEEP OF STREETS AND ROADS.

By Will P. Blair, Secretary of the National Paving Brick Manufacturers' Association.

The whole problem of streets needs to be viewed and dealt with with the same systematic business management that is applied today in the management and business of any and every private institution which has for its ultimate object progress or profit.

It is not enough in these days to know that the price paid for any particular thing is the net amount of money to be neither taken from nor added to as it is transferred from the buyer to the purchaser. Various methods are published from time to time that involve a so-called cost accounting in public affairs. Every cent is watched with exacting care from the moment that it is paid into the treasury of the city, while it lies in the cash box, its entry on the pay roll, its delivery to the contractor, or the person that performs the labor or furnishes the material. If one cent is missing, if the account does not balance, prosecution, disgrace, and punishment follow, the moment it is discovered that a cent has disappeared.

There is no objection to this oversight. No objection to the strict accountability or to the punishment that follows default or delinquency, be it dollars or cents.

But consider for one moment the ordeal thru which a road or street has to pass in every detail which contributes to its worth, the condition of the thing bought as it is delivered into your hands. Who certifies to its quality? Who records its identification? Who is held responsible even for its existence? And where of record is there any competent evidence of any official character establishing the fact that every detail of the specification has been complied with or that everything of the smallest worth has been furnished.

An executor or administrator making purchase with the dead man's money has not only to swear as to amount of cash expended,

but must swear to what he got and why the purchase was made in detail.

It serves no purpose to watch a dollar go and know that it is gone—merely to know that it is gone. The business of the transaction is to know what comes to take the place of the dollar.

Upon receipt of a new purchase for a private corporation, the most competent, the best informed, the man whose word bears the largest degree of confidence to the company in his certificate, is called upon to report whether or not the thing purchased meets the requirements and is in truth and in fact value received for the money about to be paid.

The value of a street or road for the money about to be paid is passed upon, in ninety-nine cases out of one hundred, by an agency and in a manner least competent to judge and that too without any certificate even for the worthless judgment, and much less is there any bonding force of accountability by which loss, by fraud or ignorance, can in any way be recovered.

Frequently it is a pensioner standing in the inspector's shoes, but oftentimes even worse, a blind inspection by a dignified city council or committee of that body, which, after the street is finished—there is no way of seeing any defect that should have been known before hidden underneath the surface—undertakes to pass upon and accept the job.

Nor does it compass the case by establishing a guard over the thing received, as over the cash box, no more than it will suffice to merely know what is to be paid in cash.

A street is subject to every day use; as much as any machine in a manufacturing establishment; as much so as the vehicle that travels over it.

State highway departments, collegiate institutions, and even the office of Public Roads of the United States, have deemed it advisable to construct various types of roads, and roads of like type of somewhat different construction, with a view to study, recording data, watching behavior, keeping a correct cost, maintenance and repair charge, comparing wear and tear in an endeavor to reach some conclusion and gather some testimony as to the worth and value of such

roads respectively. This endeavor on the part of these organizations is perhaps an effort as nearly practical as possible under existing circumstances. Still, in every effort of this sort, one's conclusions are drawn but from one character of travel. It is necessarily alike over the various sections. No law of averages can be applied. The conclusions reached after years of study are of doubtful character at best. The conclusions are reached from conditions that are widely different from those actually existing on our streets as a whole. The effort itself, largely artificial, does suggest, however, that no actual condition has been put to any practical purpose from which correct conclusions may be reached. And it does strongly suggest that the information sought is of great necessity. Why build a road for study? Why not study the roads built for use?

Counting traffic that passes over a street of any particular kind is no basis upon which to exercise judgment in any direction, unless that information is considered along with the knowledge of exactly what that traffic passes over. A mere name does not answer. A brick street, a stone street, an asphalt street, is meaningless for this purpose. A frame building can be built so that it will crush under the weight of a few tons. It can be built to sustain the weight of hundreds of tons.

Why cannot information of this character be obtained in a more practical and scientific manner and the information itself afford greater reliability and more adequately meet the necessities of the case?

There is no plan of street and road management or street administration that can be called fundamentally efficient, for the reason that no plan of management exists that includes in the plan a certified copy of construction, maintenance and repair, cost and identification, or any of the information sought by the building of these so-called experimental roads.

Streets which are improved are of various types.

They are in various states of repair.

They are of various locations.

Even a single street receives a variety of travel.

Single streets are often of such location that sections receive more or less travel.

The streets overlies varied conditions of soil.

Some streets are susceptible of easy natural drainage.

Other streets must receive artificial drainage.

They are generally built with the plan, specification and contract in the office of the contractor, with a foreman in charge of work who has never seen either.

The choice, the character, the type, the cost of all are subject to a greater or less extent *to the whim, the notion*, to the cheapness of cost, *influences of zealous promoters*, sometimes secured by one neighbor selling out another—in almost every case chosen from any consideration other than the ones upon which good sound judgment *should be exercised*—these streets representing one great mass of unknown conditions, evidence simply of a lavish expenditure of money known to us as the streets of this city or that—roads of this county or that.

But few of these streets and roads have a legal name, most of them bear merely a nickname. None of them bear any identification whatever or relationship to commercial accounting, such as is found in every well regulated commercial establishment.

The original investment as to its parts or its whole is not of record—at least not charged for further purpose; cost of up-keep is so confused with general charges against the whole lot that no knowledge whatever is obtainable as to the amount expended on any street or road, and we do not even know the actual reason for the expenditure, whether it was on account of repair due to wear and tear, on account of some defect of original construction, on account of accident, on account of some cut and opening; nor does any record disclose whether the street or road has remained out of repair or whether repair was needed, or whether the street or road has cost in repair an amount exceeding any justification for maintaining a road wholly inadequate for the travel and traffic that passes over it.

This chaotic and inexcusable street and road mismanagement has been allowed existence because streets and roads are sustained by donation in some one form or another, their earning capacity is not held to account. It has been allowed existence because of an existing lack of system that has become a habit, or may I suggest be-

cause up to this time this society or any other organization has not yet taken on courage sufficient to wipe it out. In a commercial establishment, if a like manner and method of conducting was permitted, the institution would soon fall into bankruptcy. A department, a machine under such loose methods would continue in operation at a loss and escape detection. No information as to the value, the worth and economy of any tool or apparatus would be possible upon which improvements could be suggested and undertaken.

I am attacking no one person or persons. I am attacking the system, rather a condition without a system, which might be characterized as a childish comedy, were it not for the fact that the play becomes a financial tragedy.

What's the matter with the streets of your city? Some are lacking in design and specification, in which case they are for the most part the old time result of "just improve the street." Covering a period of twenty years past, the streets have been improved practically without supervision—without accountability for result—with a chaotic hit and miss—no two contractors building the same design alike, but with an "I know better how to build a street than anybody"—each following his individual method, with a careful exclusion of the necessities of the specification—the result is that 90 per cent. of the defects found in streets are not due to ordinary wear and tear, but due to something else. If it is a brick or stone block street, a failure to compress the sand cushion—to make a smooth base—to wet the sides and edges of the brick—to fail to completely fill the joints with a cement filler—sins of omission; to roll the surface when the cushion is wet—to drive over and tear up the subgrade—sins of commission. On file in the city office there is no sworn record that this or that has been done or not done. The surprise is that we have so many good streets, not that we have so many poor ones.

Who in the town knows of a satisfactory street and why?

Who in the town knows of a street condemned and why?

Who knows why a street is out of repair?

Who knows why any street costs so much to keep it in repair?

Who knows how many dollars worth of labor any foreman uses in a day and how many dollars worth of work he delivers to the town therefor?

Who knows how much any street has cost for cleaning? Why so much or so little?

Would you buy a wagon with one spoke gone?

Would you buy an automobile with the differential left out?

Have I spoken too strongly? Let's apply the test. You may be operating a large business on your own account. You are about to expend \$187,000 in improving a certain department. Would you shut up in your office the only two or three competent men you have and send out to oversee the expenditure some of your most incompetent men who would be scarcely able to read the blue-prints, much less understand them, or have any capacity whatever for reasoning from cause to effect?

What business plan is there, therefore, of street and road management that could be put into operation which would serve immediate and emergency needs; which will furnish such accurate information as to original cost, cost of operation and service, usually designated as maintenance and repair, the application of such supervisory oversight as that when a break occurs it could at once be determined whether or not it was due to wear and tear or an original defect in some part? Dealing systematically with cuts and openings and replacements to effectually regulate, to the greatest advantage of the street, that annoying privilege, place upon the records of the city the street as it is and keep that record up to date. To try to get the information from a policeman is folly, to get it by way of complaint from the citizen is an outrage.

A business system must be established that is fundamental, which will bear upon everything which will secure for us an economical expenditure of money, a street best serving its purpose, removing the causes of complaint and the things complained of.

Separate these streets into certain divisions, and these divisions into sections, in no case exceeding 1 mile in length. These sections must be measured, numbered and recorded for the purpose of complete identification. To illustrate: East Forty-fifth street, division Number 9, Section 17, beginning at the north property line of Su-

terior and ending with the south property line of St. Clair, including intersections therein, 4,800 feet in length. Put such divisions in charge of a competent engineer.

You can then treat that particular section of street as a thing, a piece, as a machine; record its efficiency, watch its weakness, its strength, its value and its behavior; record information of every kind and character. Similar information can be gathered in like manner from every street within the corporate limits of the city. With the information in hand, which is possible to gather under such a plan, the adaptation of streets of type and kind for the varied services in a short time will become apparent not only to the student applying a refined study to the situation, but to the layman as well.

I have not gone into details required to put the plan suggested into working effect, that is an easy matter. Manufacturing and other business institutions find no difficulty. Disposition to do will remove all obstacles.

By such a plan of road and street management, the greatest possible economy would at once become apparent by the ability to trace the actual dollar to the thing purchased for the particular road. Aside from this benefit, data, experience and comparison would become available for future judgment. Street and road improvements, maintenance and repair would at once become a scientific, systematic, business-like operation and wasted millions would be saved.

THE PASSING AND CONSERVATION OF MACADAM CITY STREETS AND COUNTRY ROADS.

By George C. Warren, Boston, Mass.

Nearly fifteen years ago, when the development of automobile pleasure vehicles was in its infancy and the motor truck unknown and scarcely conceived, the speaker's brother, the late Frederick John Warren, based on his keen observation and foresight, frequently made the prediction that the automobile was destined to put macadam roads "out of business." Most engineers and road builders, based on greater conservatism, felt this to be an exaggerated statement. Many intimated that, in view of his enthusiasm and optimism over the bitulithic pavement he was introducing and which was then in its inception, "The wish was father to the thought." The speaker confesses that he at that time felt the prediction would not come true to nearly as great an extent as the decade and a half following has accomplished.

It is a well known fact that the present era of road building, largely at the instance both of federal and state governments, extending as it does, over a wide expanse of territory where different conditions necessarily prevail, must be conducted along the line of utilizing the material available for the purpose of rendering accessible to centers of population as large a scope of territory and accommodating as large a number of people as possible, thus giving the public the benefit of the greatest mileage of high class roads at as low a cost as is commensurate with that result. This is not only an economic question of national importance, but one of the most important before the public for consideration at this time.

There are two essentials to all good roads, no matter where built or for what purpose used, and these are proper drainage and a suitable foundation. There are now thousands of miles of macadam in use and because of lack of funds for more costly construction more will be built in the future even in places where it is recognized that macadam will not long sustain the modern exacting traffic. Certainly it is the part of wisdom to recognize this fact,

insist upon the adoption of proper drainage, and be prepared to utilize as far as possible the work already done as a foundation for a superior wearing surface when the future use of the road and the character of traffic to which it may be subjected has developed the fact that a different wearing surface from ordinary macadam pavement must be used, and the funds for improvement are economically available.

The present condition and generally accepted opinion of experts is well put in the following, extracted from the *Engineering News*, issue of August 3rd, page 226 :

Because of her early activity in road construction New Jersey has expended many millions of dollars in the construction admirably suited to the horse-drawn traffic which existed at the time the roads were built, but wholly unsuited to the motor traffic of the present day. The various makeshifts that have been tried during the past decade to enable a water-bound macadam road to stand motor traffic have involved large expense and have generally proved unsatisfactory in service. Fortunately, the last few years have seen the development of types of road surface which can withstand the stress of motor traffic and whose first cost and cost of maintenance are not prohibitive.

The speaker, however, is not one of those who argues or believes that macadam is useless, as a new construction for certain classes of roads, or that old macadam must be torn up and "wasted" to make place for a new and modern construction. He, however, does state the very firm conviction, based on broad and varied observation and experience, that macadam, whether water-bound or bitumen-coated, is not adequate to economically or satisfactorily withstand the *present* traffic of the automobile thoroughfares, which constitute probably more than 75 per cent. of the city streets and country roads thruout the United States and Canada.

He is firmly convinced that such roads not only will not withstand the ravages of the *motor truck of today*, but *much less that of the very near future*, and also believes that the motor truck which, during the past three or four years, has developed by leaps and bounds, is destined, in a very few years, to be as many fold more severe than the auto pleasure vehicle traffic of today as the latter is today more severe than the horse-drawn traffic of only fifteen years ago. We must build for the future—not merely for the pres-



Boston, Mass. Regulating old Macadam on Commonwealth Ave., at Hereford St., preparatory to laying Bitulithic Surface. Somerset Hotel in background. (Photograph taken Aug. 25, 1916.)

ent—and the engineers and road and pavement builders must appreciate, as they generally do not yet fully appreciate, that road construction must be as drastically improved as the stress on the road has been and is being drastically increased by the advent of motor pleasure vehicles and trucks. The fact is that today the average narrow country thorofare carries more and more severe traffic per foot of width than the average much wider city street, and yet “makeshift” constructions are being generally adopted on country roads, the adoption of which would not be thought of on city streets subjected to much less severe traffic.

It is a problem which must be met, and liberally and drastically met, not only by villages, cities, counties and states, but by the federal government. The recently passed federal act which appropriates increasing annual amounts (\$5,000,000, \$10,000,000, \$15,000,000, \$20,000,000 and \$25,000,000, or a total of \$75,000,000) to be expended during the next five years on post roads, at a cost to the government of not exceeding \$10,000 per mile, provided the state will at least double the amount on each road, making a total of \$150,000,000 or more, is only “a drop in the bucket,” but

is a good start in recognizing a *necessity*—"a condition and not a theory which confronts us."

New York state expended the proceeds of a \$50,000,000 bond issue in state highway construction during a few years prior to and including 1912. The expenditure of the proceeds of a succeeding \$50,000,000 bond issue is now nearing completion and during the past four years has been very largely used in reconstruction of roads built but one to four years before. The speaker predicts that many of the roads constructed in New York state during the past four years will have to be reconstructed within a very few years. In fact, many of them have already required practical reconstruction and now need the same. This, in the speaker's judgment, is not the result of "graft," but because the necessities of the case are not appreciated in the Empire state and the effort is far too much toward building the *greatest possible number of miles of road at a given expenditure, rather than to build as thoroly as possible as far as the money will go*—the former a "penny wise pound foolish" policy.

That this situation in the Empire state is being appreciated by some is shown by published statements in that state.

The Kansas City, Mo. Journal of August 17, 1916, quotes Mr. George A. Ricker, formerly one of the Deputies of the New York State Highway Commission, as stating in a public address in that city—"In New York \$4,500,000 were spent in the up-keep of roads already constructed during 1915."

The following from the New York Sun of March 24, 1916, tersely and forcefully illustrates the importance and economic necessity of building a better class of construction on country highways to enable them to successfully carry the modern auto traffic. The force of the statement is accentuated when it is known that Senator Elon R. Brown is the majority leader of the New York State Senate.

The New York Sun article is of special importance coming from the great State of New York, which has nearly completed the expenditure of the proceeds of bond issues aggregating \$100,000,000 during the past ten years, by far greater part of which is of such cheap inferior types, as referred to by the Sun, which are absolute-



Boston, Mass. Laying Bitulithic Surface over old Macadam, Commonwealth Ave., near Charlesgate, West. (Photograph taken Aug. 25, 1916.)

ly inadequate to carry even modern and much less able to carry the surely prospective auto traffic.

(Extract from *New York Sun*, March 24, 1916.)

LOGIC OF THE ROAD BUILDER.

Senator Elon R. Brown of Watertown interrupted a hearing on Wednesday on a bill designed to do the square thing by this city to say:

The entire highway system of the State is in danger of being ruined by automobile trucks.

I had a conference with Edwin Duffy, Highway Commissioner, today, and he tells me there are highways within five miles of where we are that may be ruined within sixty days.

The 'entire highway system of the State' we take to mean the State highways; and these were authorized, designed and constructed after the internal explosion engine became a fact that every road builder had to reckon with. *Were they, then, laid out without regard to the use on their surfaces of motor trucks? Was it supposed by their designers that such vehicles would avoid them, and run across lots? Or in their unsubstantial and unfit qualities is the State to learn another lesson in the science of politico-physics, with the later history of which they are so intimately connected?*

The New York Times, on April 24, 1916, published the following statement from Senator Argetsinger, another majority leader in the New York State Senate:

CALLS HIGHWAY FAULTY.

State's Maintenance Problem Is Serious, Argetsinger Asserts.

(Special to the *New York Times*.)

Albany, April 23.—*Senator George F. Argetsinger of Rochester, doubts whether the State will have a real highway system after the expenditure of \$125,000,000 by 1920. He has studied the highway problem and concludes that the maintenance of the highways is one of the most serious financial questions that now confronts the State. In discussing the matter today, Senator Argetsinger said: The people do not realize how serious the highway problem is even at this stage.*

Senator Argetsinger asserts that the State has yet to learn how to construct permanent highways. *Many miles of highways have to be entirely reconstructed and resurfaced each year, he says, and an expenditure equal to 30 per cent of the construction cost will have been made by 1920 in the maintenance of the 9,500 miles of highways which will then have been built. He believes that the present system of maintenance is faulty and requires immediate remedial legislation. He predicts a maintenance cost of \$8,000,000 a year by 1920 unless the remedy comes.*

The following is copied from the Utica, N. Y., *Observer* of Tuesday, August 15, 1916:

WASTEFUL ROAD BUILDING.

The State's Highway Department Utterly Incompetent.

Albany, in the language of its newspapers, is isolated from New York City by the almost impassable condition of about five miles of main road from Poughkeepsie. To enter the capital it is necessary to make a long dusty detour. This condition has existed since last year.

Incidental *inquiry made* in connection with the thoro investigation of State Highway work now in progress, *shows that the torn up stretch of road was plain macadam built two years before it was advertised for resurfacing in 1915.*

A little further down the road from New York there are several miles under construction near Blue Stores. This road is deterio-



Boston, Mass. Bitulithic Pavement, Commonwealth Ave., laid in 1916, showing Intersection with Dartmouth St., laid with Bitulithic over Macadam in 1903, and Hotel Vendome completed. (Photograph taken Aug. 25, 1916.)

ating at the finished end while construction is proceeding at the other end. *The new road is still a good road in the eyes of the motorist, but it already shows minor displacements that are sure signs of early disintegration.*

The road entering Albany is being built with the same inferior asphalt binder that is being used on the Blue Stores road. *There is no reason to believe, therefore, that the heavily traveled Albany road when completed will long remain in satisfactory condition.*

The present highway policy of cheapness appears also to be infecting the towns. Rhinebeck's principal street, among others on the main line between New York and Albany, reeks with tar spread with no prospect of any permanent result except the ruin of everything with which it comes in contact.

CONSERVATION OF OLD MACADAM.

This brings us to the second phase of the subject the speaker has been requested to cover by this paper.

In all said above regarding the inability of macadam (whether water-bound or surface treated) to sustain modern motor traffic and the importance of building the highest types of roads to meet the exactions of that traffic, the speaker is totally opposed to the com-

monly expressed thought that the old macadam must be wasted and a new foundation as well as new surface supplied. On the contrary, economic conservation demands that the old macadam be preserved, and, if too thin to provide a foundation for a new surface, build up on but never destroy the old macadam, and then surface with the very best available surface material.

It has been abundantly proven that this is true "efficiency and economy", and that there is no better foundation than well drained macadam which has been compacted by years of traffic.

In the speaker's home city of Boston, there are now in use approximately four hundred (400) miles of old macadam streets, practically all of which have been surface treated with oil or other materials. Fifteen years ago they were the pride of the city and an example for the country. Today they are such a vast expense to maintain that the city's laws with respect to assessment and finance for pavement are at present such as permit of nothing more than to keep most of them in barely passable condition and occasionally renew a few, altho the aggregate amount so expended in repairs is very large. It is estimated that it will require an expenditure of from twelve to fifteen million dollars (\$12,000,000 to \$15,000,000), to convert them into high grade modern pavements. It would cost nearly ten million dollars (\$10,000,000), additional if the old macadam should be torn out and new foundation supplied. Nearly three years ago Marlboro street, one of the leading East and West thorofares of the celebrated Back Bay District of Boston, had gotten in such shocking condition that its reconstruction had become a necessity. Bitulithic had been adopted by petition of the property owners and official action of the city, as the type of surface, and the question arose as to the foundation. Regrading and surfacing of the old macadam would cost approximately \$25,000. To remove and waste the old macadam and provide new portland cement concrete base would have cost at least fifteen thousand dollars (\$15,000) additional. The Commissioner of Public Works was skeptical of the plan of resurfacing the old macadam and quite insistent in providing new concrete base, notwithstanding the extra fifteen thousand dollars (\$15,000) cost. The speaker's urgent recommendation to save the macadam and fifteen thousand dollars prevailed. The work was constructed utilizing the old macadam as a



Boston, Mass. Bitulithic Pavement, Marlboro St., looking East from Massachusetts Ave., laid over old Macadam in 1914. (Photograph taken Aug. 25, 1916.)

base, as reported in considerable detail in *Municipal Engineering* of August, 1914. Immediately the traffic more than quadrupled, taking most of the traffic from less improved parallel streets. The pavement is in its third year of use; has not the slightest settlement; has not cost a penny for repairs from any cause, and stands today in perfect condition, an indisputable instance of proof of the proposition that old macadam has much economic efficient use, even if it cannot economically sustain modern traffic as a wearing surface.

The following year a larger and equally prominent thoroughfare in another section was similarly treated and has proved equally successful. During the present year Commonwealth Avenue, from Arlington street (opposite the Public Gardens), to Brookline Avenue, has been similarly reconstructed. A. S. M. I. members who attended the 1913 convention in Boston will particularly remember Commonwealth Avenue (a double roadway, each 36 to 50 feet wide with 100 foot parkway in the center), the westerly end of the work at Brookline Avenue being one block south of the Somerset Hotel, which was the official headquarters of that convention.

Turning to country roads, old macadam has been similarly surfaced during the past five years to the extent of over 300 miles in the states of Oregon, Pennsylvania, New Jersey, New York, Massachusetts and Connecticut alone.

It is reprehensible that the cement combination, officially styled the "National Portland Cement Association," representing practically every portland cement producer in the United States, which has succeeded during the past two years in universally advancing the price of cement generally about forty (40) cents per barrel, say sixty (60) per cent, and which can get nothing out of the economic utilization of old macadam as a foundation for modern pavement surfaces, persistently opposes such economic use of the millions of dollars already expended in old macadam streets and roads. It is extremely unfortunate that with the billions of dollars which must necessarily be expended in all types of modern pavements and roads any organization or individuals, and especially one having the influence of an aggregation of over a billion dollars of combined capital, would oppose such an economic conservation of a comparatively small part of it, where macadam and other old pavements suitable for resurfacing now exist. It is well to here note that a recently issued official instruction to the cement representatives in the field by the National Portland Cement Association provides:

While we should industriously promote by education and otherwise, the construction of concrete pavements, roads, alleys, etc., *we should not spend much, if any of our time, in an effort to change other types of construction to concrete where those other types will, if built, be laid on a concrete base.*

Note the correlative of this is that they will oppose the carrying out of projects for street and road improvements and the issuance of bonds therefor, unless Portland Cement is to be used in the foundation, and that the immense promotion fund provided by the large assessment against practically every barrel of portland cement manufactured in the United States has been used for the purpose of so influencing legislation. What an unbearable situation would develop if the asphalt interests, the brick interests, the lumber interests, the stone interests, the gravel interests, etc., should each similarly combine and say to the public, villages, counties, cities, states and even the Federal Government, "If you do not accept our materials (respectively) we will politically oppose legislation and



Boston, Mass. Bitulithic Pavement laid over old Macadam in 1916, on Columbia Road at Powelton Road, looking toward Hewins St. (Photograph taken Aug. 25, 1916.)

bond issues and to the best of our ability see that you get no pavement or road, nor bond issues to accomplish the end."

CAUTION.

While presenting proof of and urgently advocating the efficient and economic use of old macadam as a foundation for suitable new modern pavement and road surfaces, the speaker would fall far short of his duty if he did not add two important points of caution, to-wit:—

1. Be sure the road to be surfaced has macadam worthy of the name.
2. Be sure that the road is suitably drained.

These points having been recently fully covered in an article by the speaker published in *Good Roads*, issue of August 5, 1916, page 82, under the title, "Drain! Drain! and Drain Some More," it seems sufficient to close by the following brief statements:

1. If the old macadam has not a depth of at least four inches of solid metal, it should be reinforced by a surfacing of new metal

thoroly compressed into the old. During construction test holes should be dug in the old macadam at intervals of say one hundred (100) feet. A mere "shell" of stone which looks fairly well when dry is not sufficient, but does provide a solid construction to build upon without the expense or waste of removal. In short, save what exists and build up on that. Contracts should always provide unit prices for new materials of the several grades possibly required for building up the old macadam in sections where such test holes show more metal is required.

2. Disturb the old macadam just as little as possible, by accommodating the new lines and grades to the old as far as practicable. For instance, if the crown is too high, correct this as far as possible by raising the sides and not by excavating from the center of the road.

3. If the old street or road is not properly drained, provide such drainage, which is a comparatively simple and inexpensive operation and important, whatever kind of pavement surface or foundation is adopted. These are matters theoretically appreciated by all, but practically neglected in far too many cases by both engineers and road builders.

MR. WARREN: Since the publication of the Advance Papers of this Convention, I have received a letter from the President of the Portland Cement Association enclosing statement of policy of the Association, which, in justice to them, but without meaning to detract from the statements in the paper, I desire to read, and request their incorporation in full in the Proceedings.

Dear Sir—My attention has been called to the paper of which you are the author, published in advance by the American Society of Municipal Improvements, to be presented at the convention at Newark, October 10-13.

On page 162 you quote a paragraph from instructions to the field representatives of this association, quoting only a portion of the instructions and omitting the remainder, which is grossly misleading; in fact, the comment which immediately follows the quotation you make is not only misleading but absolutely false.

We have prided ourselves on the fact that we have made such rapid progress in the promotion of concrete as a paving material without having in any case resorted to the questionable methods which have been all too common, and which possibly may still be practiced to some extent.

I call your attention to this advance paper, feeling confident that you do not wish to make any statements which are either false or misleading.

Very truly yours,

(Signed) B. F. AFFLECK, *President*.

The statement of policy which it is stated that President Affleck has promulgated to everyone connected with the Road Bureau reads as follows:

While we should industriously promote by education and otherwise, the construction of concrete pavements, roads, alleys, etc., we *should not spend much, if any of our time, in an effort to change other types of construction to concrete where those other types will, if built, be laid on a concrete base.*

It is that much, Mr. President, of the rules which happened to come to my attention and which I quoted in the paper, which I felt, and still feel, is a fair statement of the facts. However, I wish to read the balance.

The field for the initial promotion of pavements where other types are not under consideration is so large and the results so certain that we should confine ourselves to this field rather than fight with other types in a field which is already partially covered by them.

More cement will be sold and consumed if we devote our energies to the new fields rather than contesting too strongly other types in the old field.

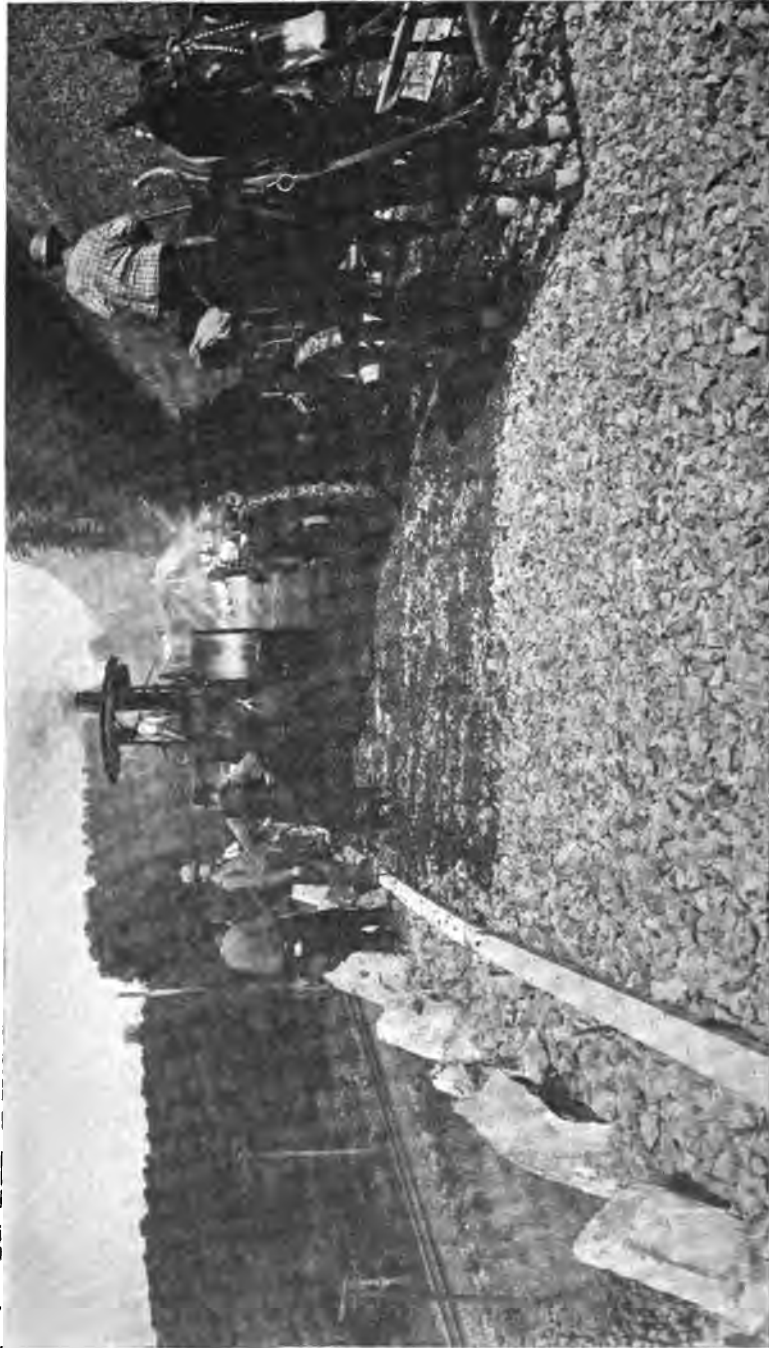
In no instance whatever let us attack bond issues or other financial schemes simply because it does not appear that the proceeds will be spent for straight concrete.

I think, Mr. President, all the statements I made are fully justified.

My interpretation of that statement of the policy of the Portland Cement Association is based in part on the performance of their representatives in the field.

I do not wish to take the time of this Convention in discussion of details, and will merely state that if the Cement Association will

consult their records and field representatives, I am certain they will find ample justification for the statements referred to in my paper. If they do not find such justification to their satisfaction and will communicate with me privately, I will give them information which is on the records of my files with respect to the matter under consideration, which is certainly ample to justify the statements of the paper.



2. Showing the spreading and rolling of the wearing surface.

HIGHWAY CONSTRUCTION IN THE NORTHWEST.

By George C. Warren, Boston, Massachusetts.

I am sure you will all be pleased at this late hour when I tell you that the subject which is announced here is ar more comprehensive than what is to be given you, the subject as published being "Highway Construction in the Northwest." What I shall undertake to do here is to stand before the screen and let you see a few motion pictures of the Columbia River Highway. Perhaps what most of you know of the Columbia River in the State of Oregon is that there is where we get our Columbia River salmon.

About two years ago there began the development of what has proved to be one of the most magnificent engineering feats in mountainous, scenic engineering which, I believe I am safe in saying, exists in this world. It is said to be a rival of the famous highways of Switzerland. In order that you may appreciate to some extent the nature of this highway I will content myself with reading what some prominent men have said about it, after trips over the Columbia River Highway Warrenite road.

Hon. Charles E. Hughes says "It is the most beautiful highway I have ever ridden over."

From an interview with Howard D. Hadley, representative of the New York *Evening Post*, on the transcontinental trip of Governor Hughes, the following is quoted: "You couldn't have shown Governor Hughes anything that would have impressed him more than the Columbia River Highway. It was built with great thoroness in an amazingly short time, at an astonishingly low cost, by the enterprise and resourcefulness and determination and self-sacrifice and public spirit of the people of a live American community. To crown it all, it is artistically sublime; beautiful dream come true. It is a perfect illustration of what Governor Hughes knows American communities are capable of. He wants to help every community do such things."

General George W. Goethals said: "The Columbia River High-



3. Near Bridal Veil.

way is a tremendous engineering accomplishment, and it is the most wonderful scenic boulevard in America."

Victor Murdock, ex-congressman from Kansas, said: "I certainly appreciated the trip over the wonderful Columbia River Highway and it shall long remain one of the brighter spots in my memory of the great West."

Mr. Louis Wiley, business manager of the *New York Times*, New York, said: "I have toured Europe and America and there is nothing anywhere like it. The highway will bring thousands of tourists to Portland. It needs only to be better known."



4. Showing tunnel thru cliff in background.



5. At Oneonta Gorge, showing concrete bridge and tunnel in background.

Mr. T. F. Ryan, banker, New York, who is not in the habit of dealing with superlatives, said: "It is the finest road in America and equal to anything in the known parts of the Old World. It's worth coming all the way from New York to see."

"That highway ought to serve as a lasting monument of those men" (Messrs. John B. Yeon and S. C. Lancaster). "This community should be proud of their work. Portland should advertise the highway extensively."

Dr. G. F. Pitts, of Warwick, N. Y., said: "The Columbia River Highway, for fine scenery and difficult engineering obstacles over-



6. At Horsetail Falls, pavement laid over concrete bridge.

come, stands unsurpassed by any other for grandeur of beauty and as a miracle of engineering science."

Mr. Isaac Gimble, New York dry goods merchant, enthusiastically remarked: "It is the most beautiful scenery I have ever seen."

I will show you first about a half dozen typical lantern slides, and then a series of motion pictures, which, I may say, were taken by the Al Kader Temple (Portland) Shriners for special use at the conclave of Shriners at Buffalo, N. Y., this summer, and illustrate the Columbia River Highway and also the Portland Rose Carnival, held in Portland in June, 1916. By a special loan of the



7. Showing Horsetail Falls at left, which is one of the most beautiful waterways along the course of the highway, bearing, however, anything but the romantic name given similar falls.

Shriners, we are able to show the film here. I mention that, not only as credit to the Shriners for their generosity, but also to show why there are some scenes which are not exactly what one would select as showing the highway as to its engineering features.



8. At Shepherd's Dell.

REPORT OF COMMITTEE ON STREET AND SIDEWALK DESIGN.

E. A. Kingsley, Chairman, Consulting Engineer, San Antonio, Tex.

Your Committee on Street and Sidewalk Design beg leave to submit for your consideration the following report:

SIDEWALKS.

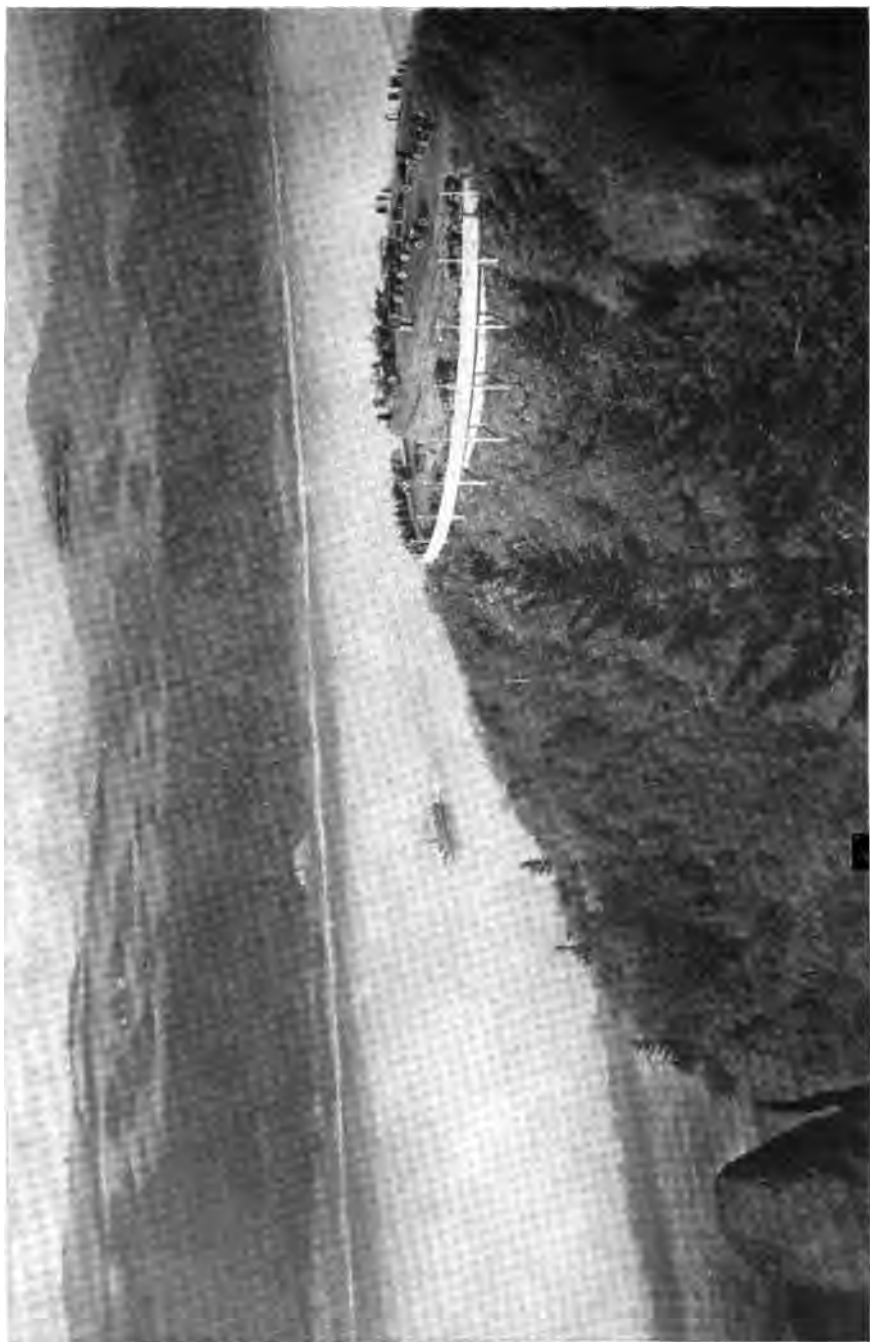
First—Position of curbing in streets in relation to the walks and location of the walks.

The curbing necessarily forms the division line or line of demarcation between the roadway and the sidewalk spacing. The curbing serves the double purpose of a barrier, preventing vehicles encroaching upon the sidewalk space, and provides a drainage way at the side of the street. Excepting in particular instances, sidewalks should always be placed on each side of the street, and the sidewalk paving should be located midway between the curb line and the individual property lines.

In special instances, such as warehouse districts, your committee would suggest as a thought that walks be omitted from the sides of the street and that a central walk be built. This would permit loading and unloading facilities next to the property lines and without interference with pedestrians.

Second—Width of sidewalk spaces and widths of parkways between the sidewalk paving and curbs.

The standard width of street may be taken at 60 feet. With a 60-foot width of street your committee would recommend that one-half the width of the street be given to sidewalk space, to be divided equally. This provides two 15-foot walks, one on either side of the street. The individual engineer for his community must govern himself as to the necessity for widening the roadway as traffic conditions require, thus narrowing the sidewalk and also widening the roadway as the street itself is widened.



The Famous View From Crown Point.

In cases of street car lines, not less than 36, and preferably 40, feet should be given as the width between curbs. Where possible, no street should be paved to a narrower width than will allow a vehicle to stand next the curb with a passing car.

Third—Slope of walk, paving and parkway.

A slope of $\frac{1}{4}$ inch to the foot from back to front of walk, dropping towards the curb, is recommended for the paving. A slope of 1 inch per foot should be allowed the parkways to provide sufficient drainage from the walk.

Fourth—Material entering into sidewalk paving.

Your committee has deemed it wise to omit reference to sidewalk paving material, inasmuch as the various standard paving committees have these specifications under consideration.

Fifth—Culvert openings and water inlets.

Considerable care should be used by the engineer in designing his inlets. A great many of the standard type inlets are sufficiently large on the face of the curb, yet their capacity is contracted because of the shallow depth from front to back. Your committee would recommend that the engineer carefully compute his run-off in each instance, and, adding a little as a factor of safety, design the opening into the curb to carry the water. In case the opening required is so large as to be objectionable in appearance or dangerous in the street, it is recommended by your committee that two or possibly three openings be made, and more of the water carried under the surface. Catchbasins should be avoided, excepting where cities have facilities for regular cleaning of the same.

Where grates are used in the gutter, they necessarily must be flush with the gutter, and the openings should be sufficiently large to allow the passage of water without becoming too easily clogged with leaves and small sticks.

Culvert openings, being a necessary evil, and detracting as a general thing from the appearance of the street, the engineer should use every effort to make them as little objectionable in appearance as possible.

STREETS.

First—Design of curbing, height, width, etc.

Your committee would recommend that the engineer study the design of his curbing somewhat from the aesthetic standpoint. In residence districts it is often best to use a rough or quarry-faced stone, especially if the street be not paved with a high-class material.

On account of the increased use of the automobile, and especially of the wire wheels, it is recommended that a batter of one in twenty from the street be given either stone or concrete curbing. It is recommended, further, that both concrete and stone curbing be given a "bull nose" of $\frac{1}{2}$ inch radius finish on the upper outer edge. Stone curbing of whatever depth should be set in concrete.

Where sidewalks are of sufficient width to permit it, it is recommended that a radius of 12 feet be adopted as a standard corner radius at all corners within 5 degrees of a right angle. At other angles the longest suitable radius should be used by the engineer to care for traffic accordingly.

Second—Treatment of intersecting grades.

Your committee would make only the suggestion that intersecting grades be looked to in each individual case by the engineer, with an eye to securing as nearly as possible a flat grade on both the intersecting streets. Each individual case must be handled separately.

Third—Drainage.

So far as is practicable, all drainage should be taken underground. In many small cities and some of the larger cities, on account of inadequate storm sewers, this may not be possible. In every instance water should be gotten rid of as quickly as is possible.

Fourth—Treatment of under-openings, conduits, signs, poles, etc.

Public service corporations and others owning poles should be required to use as neat a pole as can be secured, and these must be set far enough back from the curb so as not to strike automobile hubs.

Under-openings in the sidewalks must be treated separately and overhanging street signs and posts should be gotten rid of as far as

possible. In other words, your committee would recommend that sidewalks be cleared of every possible obstruction.

Respectfully submitted,

E. A. KINGSLEY, *Chairman*,

C. D. POLLOCK,

J. C. HALLOCK.

AMERICAN PARK SYSTEMS.

By Lawrence V. Sheridan, Landscape Engineer, Boston, Mass.

Briefly, the object of this paper is to present, for the use of the American Society of Municipal Improvements and its individual members, the results of a study carried on by the Bureau of Municipal Research of New York to ascertain the present status of park development in the United States. This investigation was commenced in February, 1915, and was pursued as time permitted up to August, 1916. Three series of questionnaires were sent to the one hundred largest cities of the country and to the more important cities of Canada. Each brought in a considerable number of replies and as a result it was possible to formulate two tables of statistics containing very complete data of the park systems of ninety-one American cities. These tables are entitled "Physical and Financial Statistics of American Park Systems" and "Administrative Statistics of American Park Systems."

An examination of these tables leads to many illuminating facts. It is at once apparent that the country as a whole is taking more rapid strides toward ideal conditions as regards recreation provisions than ever before. There is every indication that most of our cities are awakening to the fact that parks are not only a desirable part of the municipality, but that they are an absolutely necessary part. Many of the smaller cities are making liberal provisions and are following the example of those of our larger cities, unfortunately few, which had the foresight to secure their parks when land values were comparatively low. Other cities, which allowed the logical time for park acquisition to slip by, are now making strenuous efforts to remedy their deficiencies in this regard.

It is interesting to compare the conditions shown by the first table with those of a few years ago. Three of the cities, which now have excellent park systems, a comparatively short time ago had practically nothing in the way of recreation grounds. Kansas City now has 3,337 acres of parks splendidly laid out and maintained; in 1880 it had but two acres. Nearly all of its excellent system has

been acquired since 1892. Minneapolis has brought its system from but a few acres in 1883 up to 3,676 acres. Few people could be found in Minneapolis who would desire to return to the former conditions. The great Metropolitan system in and around Boston and the justly famed chain of reservations of Essex county, New Jersey, have been developed since 1890. A table, entitled "Table III, Comparison of Park Provisions of American Cities in 1880, 1905 and 1916," has been prepared to illustrate the growth of our park systems. The first column of figures is from the United States census report of 1880, the second from the census report of 1905 and the last from Table 1 of this paper. They clearly show the strides which have been taken by a number of our cities in the past thirty-five years. It is not unreasonable to expect that, in the light of our much higher state of thought as regards the necessity of proper recreation, much greater progress will be made during the next similar period.

It would seem, from a study of park history, that the greatest progress may be expected of the cities of the western and middle western sections of the country. Of the 51 cities shown west of the Appalachian Range, 29, or over one-half, have provided an acre of park land for each 300 or less inhabitants. East of the mountains but 11 of the 33 cities, or less than one-third, have made similar provisions. Moreover, of the 9 cities which have provided an acre or more of park for each 100 inhabitants, 6, or two-thirds, are located west of the Mississippi river. The western cities, as a general rule, had a greater appreciation of the need of adequate recreation space earlier in their existences and they have not been hampered to so great a degree by congestion of population and high land values as have the eastern cities. These facts point to the necessity of the smaller city making its park provisions early, even tho there is no apparent urgency.

It would be well to analyze these tables in order to appreciate the real significance of the facts which they contain. It is also necessary that the various columns be considered in their relation to each other if erroneous conclusions are to be avoided. As an example, column three of the table of physical statistics shows the percentage of the area of the whole city occupied by parks. Manhattan boro, of New York city, is shown to have 11.05 per cent. of its area in parks. This appears to be a very liberal provision. In most cities it would

TABLE I-A. PHYSICAL AND FINANCIAL STATISTICS OF AMERICAN PARK SYSTEMS.

Prepared by the New York Bureau of Municipal Research from Data collected during 1915 and 1916.

Rank as to No. of Park Acres Per 1,000 Inhabitants	City.	Area of City (Acres)	Area of Parks (Acres)	Percentage of City Area Parked	Population of City	No. of Persons to Each Park Acre	No. of Park Acres to each 1,000 Persons
37	Atlanta, Ga.	16,640	900	5.40	200,000b	222	4.50
77	Akron, Ohio	7,347	175	2.38	112,778c	644	1.55
41	Baltimore, Md.	20,160	2,321	11.51	585,000b	252	3.97
42	Birmingham, Ala.	31,648	588	1.84	150,000r	255	3.92
32	Boston, Mass.	30,295	3,517w	11.61	725,823	206	4.85
64	Bridgeport, Conn.	8,576	250	2.91	115,000b	460	2.17
59	Buffalo, N. Y.	26,880	1,229	4.57	460,000b	374	2.67
48	Cambridge, Mass.	4,182	310w	7.41	100,000r	373w	3.10
81	Camden, N. J.	5,030	140	2.78	102,465	732	1.36
25	Cincinnati, Ohio	45,440	2,476	5.44	408,000b	164	6.10
68	Chicago, Ill.	122,240	4,429c	3.62	2,393,325c	540	1.85
82	Cleveland, Ohio	33,152	2,050	6.18	720,000r	351	2.85
14	Columbus, Ohio	14,080	280	1.99	215,000r	768	1.30
2	Council Bluffs, Iowa	10,400	793	7.62	35,000c	44	22.72
13	Charleston, S. C.	3,360	667c	19.85c	72,000c	108	9.26
80	Davenport, Iowa	5,120	80	1.56	55,000c	687	1.45
94	Dayton, Ohio	10,637	48	0.45	123,794c	2,579	0.39
1	Dallas, Texas	11,520	3,494	30.33	125,000b	36	27.77
29	Denver, Colo.	37,500	1,218	3.21	250,000b	190	5.31
18	Des Moines, Iowa	32,560	720	2.08	108,147	147	6.79
75	Detroit, Mich.	26,726	1,254	4.65	723,576b	582	1.68
59	Duluth, Minn.	54,480	250	0.46	100,000r	400	2.50
71	Elizabeth, N. J.	6,080	..	..	85,000b	..	..
71	Erie, Pa.	3,120	140	2.73	80,000r	570	1.75
87	Fall River, Mass.	8,240	120	0.46	127,000b	1,088	0.94
46	Fort Wayne, Ind.	7,360	263	3.57	80,000	304	3.29
40	Fort Worth, Texas	10,768	427	3.97	100,000b	234	4.27
51	Grand Rapids, Mich.	11,200	365	3.26	125,000b	343	2.91
8	Hartford, Conn.	11,158	1,335	11.96	107,445b	81	12.42
7	Harrisburg, Pa.	6,250	960	15.36	75,000c	78	12.80

97	Hoboken, N. J.	•	640	5	0.78	73,000b	14,800	0.069
72	Holyoke, Mass.	•	14,585	104	0.71	60,816b	585	1.7107
26	Houston, Texas	•	20,480	732	3.57	129,500b	176	5.68
23	Indianapolis, Ind.	•	22,899	1,720	7.52	275,225b	160	6.25
91	Jersey City, N. J.	•	10,435	208k	1.99	300,000b	1,445	0.69
96	Johnstown, Pa.	•	3,197	10	0.31	75,000p	7,500	0.13
10	Kansas City, Mo.	•	38,163	3,337	8.74	300,000b	90	1.112
58	Kansas City, Mo.	•	11,520	260	2.26	100,000r	384	2.60
73	Lawrence, Mass.	•	4,500	162	3.60	95,000b	586	1.7055
17	Los Angeles, Cal.	•	68,480	4,000	5.84	550,000b	137	7.30
83	Lowell, Mass.	•	8,960	136	1.52	107,000r	787	1.27
98	Lynn, Mass.	•	7,253	25w	0.34	90,000r	3,600w	0.0003
27	Louisville, Ky.	•	16,832	1,482	8.80	263,256r	178	5.63
22	Memphis, Tenn.	•	12,352	1,042	8.43	165,000c	158	6.31
63	Milwaukee, Wjs.	•	22,384	922	4.06	417,054c	452	2.21
12	Minneapolis, Minn.	•	34,106	3,676	10.78c	353,460b	96	10.30
47	Nashville, Tenn.	•	11,200	434	3.87	137,000b	316	3.17
69	Newark, N. J.	•	14,976	783k	4.88k	400,000b	545k	1.83
67	New Bedford, Mass.	•	12,480	217	1.75	115,000b	530	1.88
16	New Haven, Conn.	•	11,005a	1,200	10.94	160,000r	133	7.50
45	New Orleans, La.	•	125,440	1,217	0.97	361,221c	296	3.37
76	New York, N. Y.	•	195,504	8,708	4.43	5,235,885b	603	1.66
92	Manhattan	•	43,440	1,485	11.05	2,285,761b	1,546	0.65
88	Brooklyn	•	15,328	1,693	3.74	1,855,531b	1,977	0.93
19	The Bronx	•	75,017	4,249	16.41	634,723b	151	6.62
49	Queens	•	53,111	1,186	1.56	383,233b	326	3.07
93	Richmond**	•	36,608	163	0.17	93,631b	1,486	0.67
73	Norfolk, Va.	•	10,240	132	0.17	88,000b	566	1.50
57	Oakland, Cal.	•	31,120	473	1.29	180,000c	379	2.63
24	Omaha, Neb.	•	15,360	918	5.98	150,000b	163	6.12
70	Passaic, N. J.	•	2,084	110	5.38	61,225b	557	1.80
33	Peoria, Ill.	•	16,640	485	2.62	90,000r	207	4.83
44	Philadelphia, Pa.	•	82,933	6,221	7.50	1,700,000r	273	3.66
66	Pittsburgh, Pa.	•	26,630	1,322	4.96	675,000c	510	1.96
38	Portland, Ore.	•	42,688	1,100	2.58	250,000r	227	4.40
62	Reading, Pa.	•	5,210	243	4.67	106,000b	436	2.29
50	Portland, Me.	•	12,805	182	1.32	62,000b	294	2.94
20	Rochester, N. Y.	•	16,000	1,603	10.21	245,930b	341	6.52
35	Rockford, Ill.	•	6,080	253o	4.16	55,000	153	4.60
43	St. Louis, Mo.	•	39,276	2,786b	7.04	730,000b	264	3.79
36	St. Paul, Minn.	•	34,880	1,268	3.63	276,140	218	4.59
86	St. Joseph, Mo.	•	8,480	95	1.12	85,000r	895	1.118
39	San Antonio, Texas	•	23,040	537	2.33	135,000c	233	4.30
53	San Francisco, Cal.	•	29,760	1,483	4.64	535,000c	354	2.82
78	Salt Lake City, Utah	•	32,000	154	0.48	100,000	650	1.54
60	Savannah, Ga.	•	4,352	175c	4.02	72,500r	414	2.41

65	Schenectady, N. Y.	175	3.40	82,500	471	2.12
89	Scranton, Pa.	126	1.51	140,000b	1,106	0.90
28	Seattle, Wash.	1,803	4.75	322,124b	179	5.60
30	South Bend, Ind.	9,318	3.70	67,500	193	5.18
4	Spokane, Wash.	1,939	7.99	120,000b	62	16.15
61	Syracuse, N. Y.	26,200	3.35	145,000r	423	2.37
11	Tacoma, Wash.	10,240	3.43	104,000b	90	11.06
11	Terre Haute, Ind.	25,168a	4.57	72,000b	1,360	0.78
90	Toledo, Ohio	6,428	0.82	187,000b	213	4.70
34	Trenton, N. J.	16,320	5.39	103,139b	590	1.69
74	Utica, N. Y.	4,906	3.56	84,000b	129	7.75
15	Washington, D. C.	7,680	8.48	331,069	87	11.48
9	Waterbury, Conn.	38,400	9.39	100,000r	893	1.12
85	Wilkes-Barre, Pa.	112	0.60	75,000b	377	2.65
56	Wilmington, Del.	3,078	6.46	93,000b	204	4.90
31	Worcester, Mass.	456	7.00	166,322c	153	6.504
21	Yonkers, N. Y.	24,634	1.092	95,000b	2,714	0.37
95	Troy, N. Y.	35	0.29	78,000b	821	1.22
84	CANADA—	95	0.079			
14	Calgary, Alberta	605	2.34	70,000	115	8.65
3	Edmonton, Alberta	981b	3.63	59,339b	60	16.53
54	Winnipeg, Manitoba	579	3.78	215,000	372	2.69
5	Ottawa, Ontario	1,250y		87,000	70	14.87
6	Vancouver, B. C.	1,415	3.09	100,000r	71	14.15

For foot-notes see page 171.

TABLE I-B. PHYSICAL AND FINANCIAL STATISTICS OF AMERICAN PARK SYSTEMS—CONTINUED.

City	Annual Expenditures				Annual Main-tenance Cost	Per Park Acre	Assessed of City Valuation	Basis of Valuation %
	Construction and Improve-ments	Maintenance	Total	Annual Total				
Atlanta, Ga.	\$.....	\$.....	\$ 82,101	\$0.41	.....	.....	180,942,350c	60
Akron, Ohio	9,833r	5,200r	17,553r	0.156	29.71	.....	106,112,873r	70
Baltimore, Md.	75,711e	508,248e	583,959e	0.998	218.98	.....	818,102,313c	100
Birmingham, Ala.	.....	.....	10,000	0.067	.....	.....	98,000,000	60

[illegible]

Brooklyn	789,507b	1,046,105b	0.573	617.18	1,735,518,436b	100
The Bronx	470,489b†	508,503b†	0.783†	112.85	683,331,484b	100
Queens	182,374b	223,514b	0.574	153.77	517,651,628b	100
Richmond**	j	j	j	j	86,058,929b	100
Norfolk, Va.	159,762e	235,259e	0.299	160.00o	123,800,000e	50
Oakland, Cal.	75,497e	55,000e	1.30e	58.00	38,045,153c	20
Omaha, Neb.	27,619bc	33,806bc	0.552	56.25	47,906,952b	100
Passaic, N. J.	65,000b	90,000b	1.00	149.19	24,000,000b	43
Peoria, Ill.	25,000b	951,580	0.560	112.99	1,660,206,400	100
Philadelphia, Pa.	247,628	307,478	0.455	136.36	771,024,310	100
Pittsburgh, Pa.	703,952	185,000	0.740	136.36	303,200,530r	75-50
Portland, Ore.	150,000	22,540e	0.230e	64.00m	55,197,800e	75
Reading, Pa.	15,600e	67,315b	1.085	159.38	71,843,235b	100
Portland, Me.	38,308b	170,000e	0.763e	106.05m	180,438,600e	80
Rochester, N. Y.	15,000e	187,292e	1.40	98.07	19,701,707	33 1-3
Rockford, Ill.	5,203	76,842	0.46	102.12	629,231,730	65
St. Louis, Mo.	54,000c	336,471c	0.474	70.79	114,408,085	41
St. Paul, Minn.	40,115e	130,980e	0.712	63.31	107,900,000	50
St. Joseph, Mo.	112,600b	132,600b	0.814	218.09	656,333,225	75
San Antonio, Texas	34,000	89,000	0.672	372.35	66,400,000c	35-40
San Francisco, Cal.	323,423	427,413	0.627	177.14	58,063,392r	66 2-3
Salt Lake City, Utah	57,343o	67,196o	0.170	80.15	58,125,682	80
Savannah, Ga.	15,000q	15,000q	0.208	138.54	84,405,075b	100
Schenectady, N. Y.	12,000b	15,000b	1.68	98.00m	252,362,151c	58
Scranton, Pa.	362,987e	540,341e	0.474	92.75	30,000,000	50
Seattle, Wash.	32,000	227,486e	1.85e	50.51m	90,000,000c	50
South Bend, Ind.	124,540e	237,432b	1.77	107.75	132,216,038	100
Spokane, Wash.	221,160b	139,196o	1.34	65.65	62,826,487c	50
Syracuse, N. Y.	65,893o	20,000	0.28	232.02	250,000,000b	100
Tacoma, Wash.	5,000	190,000	1.02	45.61	81,454,225b	100
Terre Haute, Ind.	150,000	101,505b	0.98	126.88	46,056,921e	100
Toledo, Ohio	79,301b	103,622e	1.281	31.00m	394,209,904r	66 2-3
Trenton, N. J.	44,028e	481,788	1.456	126.50	90,254,434	100
Utica, N. Y.	20,000	20,000	0.53	178.57	72,459,673b	70
Washington, D. C.	5,356b	39,338b	0.965	176.80	55,281,944e	75
Waterbury, Conn.	10,762e	71,194e	0.32c	36.52m	155,260,458e	100
Wilkesbarre, Pa.	11,211e	51,095e	0.22	602.34	116,781,386b	100
Wilmington, Del.	21,082	25,110	0.32	238.00	60,313,860	94
Worcester, Mass.	25,000	84,865	1.21	140.27	113,807,735	varies
Yonkers, N. Y.	22,610	49,931b	0.84	30.35	168,973,190b	100
Troy, N. Y.	20,156b	175,000c	0.814	155.44	287,365,291	75
CANADA—	40,000c	204,673f	2.0501	49.75m	214,568,910	...
Calgary, Alberta	134,260f	70,413f	...	...	...	...
Edmonton, Alberta	...	...	...	...	...	...
Winnipeg, Manitoba	...	...	...	...	...	...
Ottawa, Ontario	...	...	...	...	...	...
Vancouver, B. C.	...	...	...	...	...	...

For foot-notes see page 171

TABLE I-C. PHYSICAL AND FINANCIAL STATISTICS OF AMERICAN PARK SYSTEMS—(CONTINUED).
Prepared by the New York Bureau of Municipal Research from Data collected during 1915 and 1916.

City.	Annual Expenditure per \$100 of Assessed Valuation (Basis 100%)		Total	Mileage of Parks (Miles)	Area Devoted to Athletic Fields (Acres)	Other Departments Supervising Playgrounds and Area in Acres	Valuation of Park Lands
	Construction & Improvement	Maintenance					
Atlanta, Ga.	•	•	\$0.0027	None	•	School Grounds	\$ 2,000,000
Akron, Ohio	•	\$0.0034	0.0116	1.33	23	Social Service Corporation	334,200
Baltimore, Md.	•	•	0.0713n	8.3	126.50	None	3,678,693
Birmingham, Ala.	•	0.0092n	0.0064	•	20	School Bd. Partial Some Grds.	600,000
Boston, Mass.	•	•	0.0895n	46.08	427	Playground Comm.	66,769,340
Bridgeport, Conn.	•	0.0236	0.0738	15.34	None	School Committee	•
Buffalo, N. Y.	•	0.0389	0.0779	8.23	40	Playground Comm.	300,000
Cambridge, Mass.	•	0.0150n	0.0300n	1.20	20	Board of Education	455,000
Camden, N. J.	•	0.0650	0.0920	2.05	281	•	6,395,950c
Cincinnati, Ohio	•	0.1258	0.2358	•	•	•	24,155,268
Chicago, Ill.	•	0.1100	0.0680	•	•	•	•
Cleveland, Ohio	•	0.0280	•	•	•	•	•
Columbus, Ohio	•	•	•	•	•	•	•
Council Bluffs, Iowa	•	•	•	•	•	•	•
Charleston, S. C.	•	0.0345	0.0345	None	None	•	•
Davenport, Iowa	•	•	•	3	5	Dir. of Recreation	598,610
Dayton, Ohio	•	0.00942	0.00942	•	•	•	•
Dallas, Texas	•	0.2420v	0.2705v	•	•	•	•
Denver, Colo.	•	0.0174	0.0573	20	26.3	School Grounds	5,998,000
Des Moines, Iowa	•	•	0.0308e	18	50	Recreation Comm.	1,183,500
Detroit, Mich.	•	0.0058e	0.0367e	38.1	58.4	Dept. Public Welfare	35,595,150
Duluth, Minn.	•	0.0250n	0.0394n	25	20	•	800,000
Elizabeth, N. J.	•	•	0.6160	•	•	School Board	450,000
Erie, Pa.	•	0.0283	0.0091	3	None	Board of Education	600,000
Fall River, Mass.	•	0.0134n	0.0309n	•	50	School Grounds	750,000
Fort Wayne, Ind.	•	0.0094q	0.0297q	5.0	20	•	•
Fort Worth, Texas	•	0.0375n	0.0584n	5.0	None	•	•

Grand Rapids, Mich.	..	0.0184	0.0368	0.0552	....	31.	.....	1,159,767
Hartford, Conn.	..	0.0126	0.0470	0.0596	None	150.	Bd. of Education	2,092,906
Harrisburg, Pa.	..	0.0210	0.0348	0.0558	14.25	50.	Other Organizations 195 acres	.....
Hoboken, N. J.	..	0.0064	0.0256	0.0320	.....	0.5	.....	.....
Holyoke, Mass.	..	0.0048	0.0193	0.0241	.....	10.	.....	.....
Houston, Texas	..	..	0.0068q	0.0069q	5.0	7.0	.....	251,250
Indianapolis, Ind.	..	0.0320	0.0210	0.0340	12.0	200.0	Bd. of Education	1,500,000
Jersey City, N. J.	..	0.0117	0.0120	0.0240	20.0	32.5	Bd. of Education	4,237,293
Johnstown, Pa.	..	0.0115	0.0049	0.0640	None	4.	Bd. of Education	1,062,766g
Kansas City, Mo.	..	0.0427m	0.0480m	0.2290m	None**	104.57	None	1,500,000
Kansas City, Kans.	..	0.0876	0.0327	0.1754	10.	30.	School Grounds	14,197,433h
Lawrence, Mass.	..	0.0087n	0.0212n	0.0279n	38.63	75.0	.....	900,000
Los Angeles, Cal.	..	0.0120n	0.0180n	0.0300n	20.0	26.	Playground Dept.	10,000,000
Lowell, Mass.	..	0.0082	0.0129	0.0161	None	6.	None	558,976
Lynn, Mass.	..	0.0174	0.0169	0.0476	.....	25.	.....	500,000
Louisville, Ky.	..	0.0233n	0.0485m	0.0713m	14.2	200.	None	5,000,000
Memphis, Tenn.	..	..	0.1230	0.1490	11.32	.....	.....	6,449,554
Milwaukee, Wis.	..	0.1190n	0.0470n	0.1660n	51.62	47.	Bd. of Education	7,501,872
Minneapolis, Minn.	..	..	0.1020	0.1020	None	80.	School Yards (21)	1,500,000
Nashville, Tenn.	..	0.0026	0.0037	0.0063	.....	.....	.....	9,285,500g
Newark, N. J.	..	..	..	0.0278	None	.....	School Department	823,425
New Bedford, Mass.	..	..	..	0.0606	12.	30.	.....	4,597,768
New Haven, Conn.	..	..	..	..	.....	.....	.....	.....
New Orleans, La.	..	..	..	..	.....	.....	.....	.....
New York, N. Y.	..	0.0130	0.0303	0.0427	42.71	1948.27	Dept. of Education	632,237,785b
Manhattan	..	0.0136	0.0200	0.0336	7.59	136.45	Dept. of Education	517,746,200
Brooklyn	..	0.0148	0.0455	0.0608	28.46	326.21	Dept. of Education	48,812,680
The Bronx	..	0.0058	0.0688	0.0744	16.39	333.61	Dept. of Education	158,986,705
Queens	..	0.0080	0.0353	0.0433	0.27	154.00	Dept. of Education	6,419,600
Richmond**	..	j	j	j	.....	.....	Playground Comm.	212,600
Norfolk, Va.	..	0.0650	0.0300	0.0350	None	None	.....	4,500,000
Oakland, Cal.	..	..	..	0.0290p	35.00	39.00	.....	2,660,000h
Omaha, Neb.	..	0.0577	0.0129	0.0706	.....	.....	Playground Comm.	427,800
Passaic, N. J.	..	0.0500	0.0130	0.0630	3.0	20.0	None	700,000
Peoria, Ill.	..	0.1490	0.0424	0.0573	20.71	.....	Bd. of Recreation	16,355,447
Philadelphia, Pa.	..	..	..	0.0399	3.	.....	Bureau of Recreation	4,234,458
Pittsburgh, Pa.	..	..	..	..	.....	.....	.....	359,755
Portland, Ore.	..	0.0071	0.0213	0.0307	3.5	None	Recreation Committee	3,000,000
Reading, Pa.	..	0.0533	0.0404	0.0337	13.921	45.	None	582,2250
Portland, Me.	..	0.0065	0.0742	0.0317	.....	.....	.....	14,000,000
Rochester, N. Y.	..	0.0880	0.0420	0.1300	32.00	373.	None	3,550,000
Rockford, Ill.	..	0.0056	0.0292	0.0348	32.00	42.87	None	437,137
St. Louis, Mo.	..	0.0148n	0.0226n	0.0469n	5.	None	School Board	1,750,000
St. Paul, Minn.	..	0.0173	0.0244	0.1617	10.	116.	.....	.....
St. Joseph, Mo.	..	0.0382	0.0236	0.0618	.....	.....	.....	.....
San Antonio, Texas	..	..	..	..	.....	.....	.....	.....

San Francisco, Cal.	.....	0.0079	0.0245	0.0324	.....	30.43	Playground Comm.	.....
Salt Lake City, Utah	.....	0.0055	0.0324	0.0379	1.26	8.25	Playground Comm.	6,177,500
Savannah, Ga.	.....	0.0172n	0.0156n	0.0327n	9.	24.	Board of Education	420,000
Schenectady, N. Y.	.....	.....	0.0193	0.0193	2.5	30.	.....	.....
Scranton, Pa.	.....	0.0142	0.0177	0.0346	None	4.	School Bd. (120 Acres)	9,110,817
Seattle, Wash.	.....	0.0690n	0.0330n	0.1020n	31.0	143.	.....	556,097
South Bend, Ind.	.....	.....	0.0540	0.0540	.....	.....	.....	1,500,000
Spokane, Wash.	.....	0.0892n	0.0544n	0.1236n	15.0	103.	None	2,005,400b
SYRACUSE, N. Y.	.....	0.1873	0.0274	0.1947	7.	45.5	.....	1,648,510
Tacoma, Wash.	.....	0.0532	0.0600	0.1132	.....	None	.....	783,500
Terre Haute, Ind.	.....	.....	0.0160	0.0760	21.	12.	Dept. of Education	1,330,030
Toledo, Ohio	.....	0.0500	0.0160	0.1246	.....	.....	.....	400,000
Trenton, N. J.	.....	0.0373	0.0223	0.1246	.....	40.0	None	250,000
Utica, N. Y.	.....	0.0955	0.0432	0.2550	5.80	.....	Supervisor of Playgrounds	1,000,000
Washington, D. C.	.....	.....	0.0315	0.0816	13.00	.....	Associated Charities	3,886,280
Waterbury, Conn.	.....	.....	0.0222	0.0222	.....	16.	School Board	1,498,460
Wilkesbarre, Pa.	.....	0.0057	0.0328	0.0386	2.5	21.	Water Dept.	.....
Wilmington, Del.	.....	0.0146	0.0286	0.0986	0.3	41.73	Playground Comm. (740)	327,000
Worcester, Mass.	.....	0.0072	0.0257	0.0329	None	None	Bureau of Recreation	1,000,000
Yonkers, N. Y.	.....	.....	0.0179	0.0179	.....	14.	.....	.....
Troy, N. Y.	.....	0.0390	0.0353	0.0392	.....	.....	.....	.....
CANADA—	.....	.....	.....	.....	.....	.....	.....	.....
Calgary, Alberta	.....	0.0530	0.0530	0.0530	.....	209.75	School Board	1,313,870
Edmonton, Alberta	.....	0.0119	0.0176	0.0295	29.78	259.50	Playground Comm.	3,317,580
Winnipeg, Alberta	.....	0.0107	0.0242	0.0349	127.	.....	.....	3,287,000
Ottawa, Ontario	.....	.....	.....	.....	.....	.....	.....	.....
Vancouver, B. C.	.....	0.0620n	0.0330n	0.0950n	None	2.13	School Board	.....

FOOT-NOTES.

a—Land area only. b—Figures for 1915. c—Figures for 1914. d—Average for four years. e—Average for five years. f—Average for three years. g—Does not include county park. h—Cost to date of system. i—Includes those in parks. j—Boros of Manhattan and Richmond combined. k—Includes county parks within city limits. l—Average total expenditure divided by present population. m—Average maintenance cost divided by present acreage. n—Average annual expenditures divided by present assessed valuation reduced to 100 per cent. o—Figures for 1913. p—Figures based on 3,220 acres of parks. q—Average. r—Figures for 1916. s—Does not include mountain parks. t—Does not include baths and beaches. u—Figures for ten months. v—Based on ten months' expenditures reduced to annual basis. w—Does not include Metropolitan Park Board holdings. x—Based on 1,170 acres under jurisdiction of office of public buildings and grounds. y—Does not include three of the small commissions. z—Includes Experimental Farm of 400 acres. A semi-public park. z—Does not include Keney Park. *—Statistics furnished by city officials. **—79 miles planned. ***—Figures included in those for Manhattan. †—Not including Botanical Gardens and Zoological Gardens or Bronx Parkway.

be, but in Manhattan there is but one acre of park for each 1,546 inhabitants. Its unequaled density of population renders an ordinarily liberal provision of parks entirely inadequate. Few cities suffer as great a park need as Manhattan. On the other hand, Kansas City, with a much less percentage of city area parked (8.74 per cent.), has provided an acre of park for each 90 inhabitants. Kansas City has only about one-half the number of people to the park acre that New York has to the city acre. These are extreme examples but indicate the necessity of considering all available facts in interpreting park statistics.

It is not possible to set up a standard percentage of city area which should be devoted to recreation purposes. There are too many factors to be considered in determining the space needed. The average of the cities from which data were received is about 5 per cent., varying between 30.33 per cent. in Dallas, 19.85 per cent. in Charleston, S. C., 16.93 per cent. in Bronx boro of New York city, and 15.36 per cent. in Hartford, on the one hand, and Dayton, 0.45 per cent. and Yonkers, N. Y., 0.29 per cent. on the other.

It would be easier to set up a standard for the number of persons to the park acre. The average of all the cities (except Hoboken, Johnstown and Lynn) is 450. This includes the cities in which conditions are known to be bad. In fact, but few have reached a condition approaching closely the ideal. Kansas City would not admit that it should have less area than it has, which provides an acre of park for each 90 persons. It is, instead, going ahead and providing more park area continually. Certainly every city should have an acre for each 200 persons, and considering carefully the more desirable living conditions in the cities which have made better provisions than this, it does not seem unreasonable to say that every city should endeavor to provide an acre of recreation space for each 100 of its inhabitants.

In studying the problem for a particular city other things must be taken into consideration. The most important of these is housing conditions. A city with living conditions approximating those of Manhattan boro and portions of the other boros of New York City, of other large cities and of many of the manufacturing cities of the east and the "slums" of other cities, suffers a much greater need for parks than do those communities in which most of the homes are

surrounded by spacious lawns. So again it is apparent that these figures must not be taken for granted. They should be qualified by a study of other local conditions if a specific use is to be made of them.

The columns following the physical statistics give general data as to the expenditures for "Construction and Improvements," for "Maintenance" and for "Activities" of all sorts. These have been used to compute two columns for the comparison of conditions in different cities. The first of the computed columns shows the cost per capita per annum of all park expenditures and the second the cost per park acre for maintenance. In a few cases average figures were submitted covering periods of three, four or five years. These, in view of the fact that improvement expense varies so much, are much more valuable. Wherever average figures were used a note of the fact appears in the table.

Some interesting facts were uncovered by the data received. For example, Dallas, a city of 125,000 population, expended \$5.04 per capita per annum. This is a surprisingly large expenditure, but is due to the fact that Dallas is just now acquiring land which will serve its needs for many years to come. Its per capita cost will undoubtedly decrease and the future will show the wisdom of acquisition of park lands in time. Kansas City, however, with a highly developed system, reported an average of \$3.96 per capita per annum over a four-year period. Its excellent parks and their effect upon living conditions evidence the wisdom of sufficient expenditures for recreation grounds. Chicago, with a large area, expends \$2.75, and Minneapolis spends \$2.34 upon its excellent system. Thruout the list the expenditures per capita indicate quite closely the standing of each park system as regards adequacy.

It is difficult to compare the maintenance costs of various cities. Even in the same city it is impossible to compare costs per acre of two parks unless they are developed alike, have the same soil conditions, use, etc. As an example of the futility of comparing maintenance unit costs the cases of Newark and Kansas City may be cited. The figures for the former apply only to the small squares under the jurisdiction of the Shade Tree Commission. They are highly developed and are intensely used. The Kansas City figure

applies to parks, large and small, and parkways, which are in many stages of development. The cost in Kansas City is only about one-seventh of that in Newark per acre, yet there is slight difference in the standard of upkeep.

The maintenance unit costs are, however, valuable. They may be used in a general way for comparing the attention paid to maintenance in various cities.

The assessed valuation of cities and the resultant figures showing costs per \$100 of assessed valuation of construction and improvements, maintenance and all activities, offers a further means of comparing the importance attached to parks by different cities. It is of further value to those cities which receive all or part of their park funds by a mill tax. It should be remembered in making comparisons that the assessed valuation has been converted in each case to a 100 per cent. basis in order that all would be on the same basis.

The column headed "Mileage of Parkway" was added in order that some indication of whether the parks of a city formed a system or whether they were merely isolated fragments of a possible system might be made. Quite a large number of the cities report no parkways. These communities have much work before them before they may say that they have made the most of their opportunities. Other cities indicate that they have given much attention to this important feature of the design of a park system. Kansas City has 60.85 miles of parkways and boulevards in use and plans to build 79 miles more. Minneapolis has 51.62 miles. Boston has built 45.08 miles and a number of cities on the list have over 10 miles. Some of the cities which did not report their mileage, Chicago for example, also have several miles.

The two columns on recreation, while admittedly incomplete, indicate to some extent the attention which is being given to active recreation by park departments. This is a very live problem and the amount of space to allow for each kind of recreation is a matter which the designer finds difficult to solve. It is necessary that very careful studies be made of the various uses to which park property is put and that general percentages of total space for each use be determined. The Bureau of Municipal Research is contemplat-

ing such a study of New York parks. It is intended that censuses be taken at various seasons of the year of the use made of each facility. From such a study it may be possible to determine whether or not sufficient space is given to each activity, at least whether or not it secures its proper proportion of the available space. It would be of immense value if such studies could be undertaken in other cities concurrently with the New York study. The Bureau of Municipal Research would welcome the opportunity to exchange ideas with those interested in such matters.

The last column, valuation of park lands, contains interesting information but of less actual value than that contained in the other columns.

The second table contains the information received relative to methods of administration. The primary purpose of its preparation was to bring together, in brief form, information as to the prevailing forms of park management and, if possible, to determine which form of administration had been most successful in not only planning, but in actually accomplishing, park developments.

The answers received showed that in the 91 cities there were 50 non-paid boards, 7 paid boards (most of which received low salaries), 27 paid commissioners or directors, and 7 miscellaneous forms of administration. Among the cities which have developed adequate park systems almost all have the non-paid board administration, Chicago, Kansas City, Minneapolis, Hartford, Dallas, Cincinnati, Indianapolis and others still retain this form of administration. Rochester and St. Louis had similar forms until quite recently. Due to the advent of commission and commission-manager forms of city government, a number of park boards have been abolished. Many of them had good records but were not thought to be in accord with the new forms of government and were consequently not provided for in the new charters. These numerous changes should cause careful consideration as to their possible effects by those interested in good city government in general and parks in particular.

Theoretically, park functions are entitled to no more special consideration in the formation of the city charter than are any of the other major functions of the government. Generally, however, the

development of a park system has been the last of the necessary projects to be undertaken. It has usually been allowed to lag so far behind the other essential provisions that the average city administration, even when it realized the necessity, hesitated to advocate the seemingly large expenditures required to bring parks up to their proper place. In such cases it was found necessary to provide a more or less independent board, composed of men who were not bound by their political connections, for the special purpose of planning and carrying out a park development scheme. Frequently this was done in the face of violent opposition; opposition which no political administration could face and expect its existence to continue. In order that the boards might live thru the opposition period, they were generally continuing boards—that is, the term of but one member expired each year. That such a form of administration has been successful is amply demonstrated in the cities which have developed adequate park systems. Few of importance have been developed under any other form of management.

There is a further reason for the success of such boards. Their membership has generally been composed of men of force in the communities, men who, by reason of their broad experience and position, their sound sense of business or their force of character, have been worth more than any salary which the city was able to pay them. This is more particularly true of park boards. The nature of park work is more attractive to citizens of this type than that of other activities, such as sewer or highway work. For this reason it is less difficult to secure this desirable type of men for park boards than it would be for a non-paid board, charged with other undertakings. It is not mere theory which has just been advanced. Almost every city which has developed a real park system has done it thru the courage and determination of one or more citizens giving freely of their services.

Where similar park conditions to those which have required special efforts to better in the past, exist in cities under the new forms of government, it is questionable whether or not they can be improved without special forms of administration. Certain it is that some one must take it upon his shoulders to advocate the carrying out of a large program. This generally means an educational campaign and the overcoming of opposition, engendered by ignorance

or suspicion of motives. Unless he has the backing of the entire administration, such a course may jeopardize his position if he is a paid city employe. It is too much to expect; where men have the vision but are dependent upon the salary which the city pays them for their livelihood, that they will advocate a plan so strongly as to lose their positions. Few of those who forced the development of parks in the past would have remained long in office if they had been in the paid employ of the city. It is in just such cases as this that the non-paid board has been necessary. One remedy, however, lies with the civic organizations. Very often, unfortunately, these societies have given too much attention to destructive criticisms of city officials and not enough to the advocacies of constructive programs. There is a big opportunity in this direction for chambers of commerce, bureaus of municipal research and other organizations of citizens to secure the improvement, not only of park conditions, but of other facilities which have been allowed to lag behind. Many of the advantages of the non-paid boards may be retained in this way.

The last columns of Table 2 were added to show which cities had gone about the improvement of their park systems in an intelligent and business-like manner. It is gratifying to note that over half of the cities listed have adopted complete, or at least partial, development plans before going ahead with the acquisition of land and its improvement. Doubtless many of those which have not already done so will take this important step in their park development in the future. The results of early planning are seen in the parks of Kansas City, Boston, Minneapolis, and the other leading systems of the country.

In conclusion, it should be stated that it would be very desirable to extend the scope of this study and include all cities of the United States and Canada. Many communities, of less than 25,000 even, are going ahead with very commendable park developments. More detailed information could also be collected to advantage. Their work should be made known to those interested in such matters. The Bureau of Municipal Research has recently prepared a bulletin containing these tables and explanatory text. As time permits, it will go ahead with the collection of further data. This society, thru the agency of its park committee, will also probably undertake further park studies.

TABLE III. COMPARISON OF PARK PROVISIONS IN AMERICAN CITIES IN 1880, 1905 AND 1916.

Census Report of 1880.

	Population	Area Parks (Acres)	Number of Persons per Park Acre
Akron, Ohio	16,500	25	660
Albany, N. Y.	91,000	75	1,213
Baltimore, Md.	232,500	749	310
Boston, Mass.	363,000	106	3,424
Bridgeport, Conn.	28,000	100	280
Brooklyn, N. Y.	567,000	505	1,122
Buffalo, N. Y.	155,000	350	442
Cincinnati, Ohio	255,000	370	689
Chicago, Ill.	503,500	1,780	282
Council Bluffs, Iowa.	18,000	793	22
Denver, Colo. ....	.....	.....	.....
Detroit, Mich.	116,500	700	166
Fall River, Mass.	49,000	54	907
Fort Wayne, Ind. ....	.....	None	.....
Indianapolis, Ind.	75,000	90	833
Kansas City, Mo.	56,000	2	28,000
Minneapolis, Minn. ....	.....	.....	.....
New Orleans, La.	216,000	425	508
New York (Manhattan)	1,206,500	862	1,400
Omaha, Neb.	30,500	73	417
Philadelphia, Pa.	847,000	2,740	309
Pittsburg, Pa.	156,000	1	156,000
Portland, Me.	34,000	50	680
Rochester, N. Y.	(Unknown)	.....	.....
Providence, R. I.	105,000	103	1,019
Salt Lake City, Utah	21,000	40	525
San Antonio, Tex.	20,500	50	410
San Francisco, Cal.	234,000	1,050	222
Savannah, Ga.	31,000	60	516
Scranton, Pa.	51,000	.....	.....
St. Paul, Minn.	41,500	240	172
St. Louis, Mo.	350,500	1,986	176
Trenton, N. J.	30,000	None	.....
Wilmington, Del.	42,500	None	.....

Census Report of 1905.

	Population	Area Parks (Acres)	Number of Persons per Park Acre
Akron, Ohio	52,078	98	531
Albany, N. Y.	99,268	315	315
Baltimore, Md.	561,120	2,072	271
Boston, Mass.	609,175	2,756	221
Bridgeport, Conn.	86,487	250	346
Brooklyn, N. Y.	(Not separated into boros)	.....	.....
Buffalo, N. Y.	386,724	1,052	368
Cincinnati, Ohio	347,123	460	754

Chicago, Ill.	2,107,620	3,412	618
Council Bluffs, Iowa.....	(Not given)		
Denver, Colo.	153,524	1,037	148
Detroit, Mich.	367,494	1,199	306
Fall River, Mass.	106,121	99	1,702
Fort Wayne, Ind.	52,219	96	544
Indianapolis, Ind.	227,698	1,317	173
Kansas City, Mo.	185,479	2,055	90
Minneapolis, Minn.	285,676	1,927	158
New Orleans, La.	318,652	1,217	261
New York (Manhattan)	(Not separated into boros)		
Omaha, Neb.	127,768	613	208
Philadelphia, Pa.	1,466,408	4,175	351
Pittsburg, Pa.	531,527	1,275	417
Portland, Me.	56,000	106	528
Rochester, N. Y.	189,384	1,456	130
Providence, R. I.	207,850	644	323
Salt Lake City, Utah	62,216	120	519
San Antonio, Tex.	64,275	352	182
San Francisco, Cal.	342,782	1,399	245
Savannah, Ga.	69,880	165	423
Scranton, Pa.	121,343	97	1,251
St. Paul, Minn.	210,606	1,401	150
St. Louis, Mo.	661,666	2,198	301
Trenton, N. J.	88,529	150	590
Wilmington, Del.	86,420	294	290

Bureau of Municipal Research Statistics.

	Population	Area Parks (Acres)	Number of Persons per Park Acre
Akron, Ohio	112,778	175	644
Albany, N. Y. ....	.....	.....	.....
Baltimore, Md.	585,000	2,321	252
Boston, Mass.	725,823	3,517	206
Bridgeport, Conn.	115,000	250	460
Brooklyn, N. Y.	1,825,534	1,695	1,077
Buffalo, N. Y.	460,000	1,229	374
Cincinnati, Ohio	408,000	2,476	164
Chicago, Ill.	2,185,283	4,388	498
Council Bluffs, Iowa.....	85,000	793	44
Denver, Colo.	250,000	1,318	190
Detroit, Mich.	723,976	1,244	582
Fall River, Mass.	127,000	120	1,068
Fort Wayne, Ind.	80,000	263	304
Indianapolis, Ind.	275,255	1,720	160
Kansas City, Mo.	300,000	3,337	90
Minneapolis, Minn.	353,460	3,676	96
New Orleans, La.	361,221	1,217	296
New York (Manhattan)	2,295,761	1,485	1,546
Omaha, Neb.	150,000	918	163
Philadelphia, Pa.	1,700,000	6,221	273
Pittsburg, Pa.	675,000	1,822	510
Portland, Me.	62,000	182	341
Rochester, N. Y.	245,930	1,603	153
Providence, R. I. ....	.....	.....	.....

Salt Lake City, Utah	100,000	154	644
San Antonio, Tex.	125,000	537	233
San Francisco, Cal.	525,000	2,000	262
Savannah, Ga.	72,500	175	414
Scranton, Pa.	140,000	126	1,106
St Paul, Minn.	276,140	1,268	218
St. Louis, Mo.	730,000	2,766	264
Trenton, N. J.	103,139	175	590
Wilmington, Del.	93,000	456	204

CARE OF BIRDS IN PUBLIC PARKS.

*By H. S. Richards, Superintendent of Maintenance and Repair,
South Park Commissioners, Chicago, Ill.*

The interest of the South Park Commissioners was first aroused in the matter of attracting and protecting wild birds several years ago and since then the care of birds has become one of the regular items of park maintenance work. From time to time valuable information and suggestions have been gathered from naturalists and bird lovers, among whom I may mention Mr. J. R. Griffith and Jack Fulton, Jr., both of whom are well posted and enthusiastic on this subject.

The main points requiring attention are the supply of nesting boxes and nesting material, the feeding of the birds in winter and protection from the annoyance of the public or from animals, such as cats.

During the past few years several hundred wren, bluebird and woodpecker houses have been placed in trees in different parks and I have noticed that they are very well patronized by the birds. I doubt if there was a wren house that didn't have a pair of wrens in it this year. Enough martin houses to provide for about a thousand birds have been placed on the tops of poles twelve to fifteen feet above ground in the larger parks and every year large colonies of martins occupy them. As martins are rather sociable birds the houses are usually located in groups in quiet spots where they will not be molested by park visitors. As the English sparrows are very anxious to take possession of these houses whenever they have a chance, we close the houses after the martins leave in the fall and open them just before they arrive in the spring. In this way we are able to keep the sparrows out to a very large degree. The poles on which the martin houses are mounted are covered a part of their length with tin to prevent cats or squirrels climbing them. Early in the spring nesting material, usually loose waste, is hung here and there in the shrubbery where the birds can easily find it.

During the fall, winter and early spring food is furnished to the

birds. This is a mixture composed of the following articles:

Hemp seed—200 pounds.

Millet seed—100 pounds.

Sunflower seed—100 pounds.

Mixed "chicken feed"—200 pounds.

Oats (whole grain)—4 bushels.

In the larger parks where the mixture is fed fast enough to prevent the ground meat from spoiling, the following articles are added to the above mixture:

Ground beef—20 pounds.

Ground beef suet—10 pounds.

Ground stale bread—6 loaves.

In Washington and Jackson Parks elevated feeding platforms are provided at various places in the shrubbery. These platforms are about six feet above ground, are mounted on single iron pipe standards and covered with rather widely spreading thatched roofs. Men are assigned to place the feeding mixture on these platforms daily during the fall, winter and early spring months; feed is also scattered in sheltered spots on the ground near the trunks of trees or beside clumps of shrubbery, where it can be readily found by the birds. The sparrows flock to the feeding grounds in great numbers after a snowfall and consume considerable feed; nothing special has been done thru the use of sparrow traps or otherwise to eliminate them.

Small wire-mesh baskets or cages curved to fit the trunks of trees have been hung in the trees at various places. These are filled with ground suet in the effort to induce such wild birds as relish that food to remain over winter.

Shrubs having berries in the fall and early winter furnish considerable food to birds. Many benefits are derived from the presence of insect-eating birds in the parks in destroying harmful insects. This subject is a very interesting one and might be elaborated upon considerably but I shall not attempt to do so in this paper.

The efforts of the South Park Commissioners in inducing wild birds to make their homes in the parks have met with gratifying

success. Signs have for some years been posted in the parks requesting the public to assist the commissioners towards this end by not molesting the birds and the people appear to have readily co-operated in this regard. The general public is undoubtedly unaware of the presence of many varieties of birds which are naturally shy and are as a rule found only by those who make special efforts to find them. Perhaps the best suited locality in any of the south parks for birds is the Wooded Island in Jackson Park. This large island is well supplied with an abundance of trees and shrubbery around its margin; it is surrounded by lagoons, while in the center are well kept lawns, making it a favorite resort for birds of many kinds. In 1914 Jack Fulton, Jr., found 114 kinds of birds and waterfowl in Jackson Park between March 1 and May 20, and most of them were seen on the Wooded Island. His list follows:

Kind of Bird.	Found At.	Date Seen.
Belted kingfisher	Wooded Island	March 26
Hairy woodpecker	Wooded Island	March 2
N. downy woodpecker	Wooded Island	March 6
Yellow bellied sapsucker	South edge of park	April 4
Red-headed woodpecker	Wooded Island	April 25
Flicker	Wooded Island	April 6
Whip-poor-will	Wooded Island	April 24
Kingbird	Wooded Island	April 27
Crested flycatcher	Wooded Island	May 20
Phoebe	18-hole golf course	March 30
Olive-sided flycatcher	Wooded Island	May 20
Wood pewee	Wooded Island	April 27
Least flycatcher	Wooded Island	April 29
Yellow-billed cuckoo	Wooded Island	April 29
Blue jay	Wooded Island	March 1
Crow	Inner harbor	March 1
Cowbird	Wooded Island	March 28
Red-winged blackbird	Swamp	March 31
Meadow lark	Around park	March 31
Baltimore oriole	Swamp	April 27
Rusty blackbird	Swamp	March 25
Bronzed grackle	Wooded Island	March 14
Purple finch	Peninsula	April 13
Gold finch	Wooded Island	April 13
Pine finch	Wooded Island	May 20
Vesper sparrow	Around park	April 14
White-crowned sparrow	Wooded Island	May 4
White-throated sparrow	Wooded Island	April 15
Tree sparrow	Swamp	March 14
Chipping sparrow	Around park	April 12
Field sparrow	Around park	April 18
Slate-colored junco	Swamp	March 14
Song sparrow	Around park	March 8
Swamp sparrow	Swamp	March 8
Fox sparrow	Around park	March 28
Towhee	Swamp	March 28
Rose-breasted grosbeak	Wooded Island	March 28
Scarlet tanager	Wooded Island	May 4
Purple martin	Around park	April 21
Barn swallow	Around park	April 25
Tree swallow	Around park	April 16
Bank swallow	Around park	April 24
Cedar waxwing	Wooded Island	May 17
Loggerhead shrike	Wooded Island	March 6
Yellow-throated vireo	Wooded Island	April 25
Black and white warbler	Around park	April 15

Prothonotary warbler	Wooded Island	April 28
Lawrence warbler	Wooded Island	May 4
Nashville warbler	Wooded Island	April 28
Tennessee warbler	Wooded Island	May 17
Parula warbler	Wooded Island	April 29
Cape May warbler	Wooded Island	April 30
Yellow warbler	Wooded Island	April 27
Black-throated blue warbler	Wooded Island	May 4
Myrtle warbler	Wooded Island	April 6
Magnolia warbler	Wooded Island	May 2
Chestnut-sided warbler	Wooded Island	May 4
Bay-breasted warbler	Wooded Island	April 29
Blackburnian warbler	Wooded Island	May 4
Black-throated green warbler	Wooded Island	May 1
Palm warbler	Peninsula	April 21
Prairie warbler	Peninsula	May 6
Oven bird	Wooded Island	April 28
Water thrush	Wooded Island	May 4
Connecticut warbler	Wooded Island	May 17
Maryland yellow throat	Peninsula	May 2
Canadian warbler	Wooded Island	May 17
Redstart	Wooded Island	April 27
Catbird	Around park	
Brown thrasher	Around park	
House wren	Wooded Island	April 25
Winter wren	Wooded Island	April 14
Brown creeper	Wooded Island	April 6
White-breasted nuthatch	Wooded Island	March 1
Red-breasted nuthatch	Wooded Island	April 26
Black-capped chickadee	Around park	March 1
Golden-crowned kinglet	Around park	April 6
Ruby-crowned kinglet	Around park	April 6
Blue-gray gnatcatcher	Wooded Island	April 15
Wilson thrush	Wooded Island	May 1
Olive-backed thrush	Wooded Island	April 27
Hermit thrush	Wooded Island	April 6
Robin	Around park	March 14
Bluebird	Wooded Island	
Herring gull	Around park	March 1
American merganser	Lagoons	March 8
Old squaw duck	Lagoons	March 14
Blue-winged teal	Lagoons	March 18
American goldeneye	Lagoons	March 19
Pied-billed grebe	Lagoons	March 25
Red-breasted merganser	Lagoons	March 30
Lesser scaup duck	Lagoons	March 30
Ringnecked duck	Lagoons	March 31
Buffleheads	Lagoons	April 1
Bonaparte gull	Around park	April 6
Woodcock	Wooded Island	April 6
Broad-winged hawk	South edge of park	April 6
Screech owl	Wooded Island	April 7
Hooded merganser	Lagoons	March 31
Killdeer	Around park	March 31
Sparrow hawk	Around park	April 11
Sharp-shinned hawk	Around park	April 14
Cooper hawk	Around park	April 18
Ruddy duck	Lagoons	April 18
Spotted sandpiper	Around park	April 18
Wilson snipe	Wooded Island	April 18
Coot	Lagoon	April 15
Ring-billed gull	Around park	April 21
Black tern	Lagoon	April 21
Red-shouldered hawk	Around park	April 21
Green heron	Around park	April 21
Florida gallinule	Lagoon	April 25
Common tern	Around park	April 25
American bittern	Wooded Island	April 28

RECENT DEVELOPMENTS IN THE THEORY AND PRACTICE OF STREET LIGHTING.

By Preston S. Millar, General Manager, Electrical Testing Laboratories, New York City.

The illuminating engineering point of view does not comprehend simply one aspect of the street-lighting question; rather it is the whole question, for all aspects of street illumination which are open to discussion receive attention for the reason that the public requires the illumination of streets at night. The municipality appropriates large sums of money and secures the services of an engineering department in order to provide for the illumination of streets. The adequacy and acceptability of the illumination which is produced are the measures of the purchase made with the money appropriated. To provide twice as much street illumination, a municipality is usually prepared to expend an amount which is almost double. How much is the average municipality prepared to expend for a street illumination which is twice as good and how much is such improved illumination worth to the municipality? Such considerations must be regarded as important by this society, and they lead at once to the question of merit in street illumination and how it shall be measured. What does a municipality want to secure for money expended in street illumination and how shall it be measured? What, after all, is the measure of street illumination in terms of which the municipality should be prepared to fix its expenditure?

Two years ago a joint street-lighting committee, composed of the committees of the National Electric Light Association and the Association of Edison Illuminating Companies, addressed itself to the question, what is the purpose of street illumination? After collecting opinions from committee members and other qualified observers, this joint committee formulated the following condensed statement, which, in the writer's opinion, is the best expression which has been given of these purposes:

The purposes of street illumination are, primarily, to reveal ob-

jects on the street, to reveal irregularities in the street surface and to render the street attractive.

This terse statement comprehends many diverse objects which street lighting is expected to serve at different times and in different localities. It comprehends all but a few secondary requirements, which, after all, are likely to be served incidentally whenever these major purposes are served.

Having formulated best available ideas as to the purposes to be served by street illumination, this joint committee undertook an investigation of some conditions of street lighting, basing its procedure on the proposition that street lighting is effective in proportion as these three major purposes are served. This entailed means for measuring the extent to which each of the purposes was accomplished and led to the development of methods of test which supplied, it is safe to say, a better measure of the revealing powers of street illumination than has ever before been available. In considerable detail these methods of test have been described and the results of the studies which the committee carried out have been set forth in their several reports, to which reference is made.*

In addition to the numerically expressed results which have added considerably to our knowledge of street illumination, this work, as will be readily appreciated, proved very instructive to those who participated in the investigation. There is obviously no better way to arrive at correct views on any subject or to crystallize indefinitely entertained ideas on any subject than to endeavor to arrive at a consensus or to reduce them to numerical expression. For example, in the matter of glare it was found that endeavors to ascertain how well or poorly objects could be seen under different illuminating systems led to very definite and concordant opinions as to the degree to which glare proved objectionable. As the investigation continued over a period of more than a year and was participated in by scores of engineers, a great mass of data was accumulated and many men interested in street lighting had the opportunity to form independent opinions under conditions affording unexampled opportunities for stimulating their ideas on the subject. Not the least of

*Transactions National Electric Light Assn., 1914, page 589.

Transactions National Electric Light Assn., 1915, page 710.

"Tests of Street Illumination," P. S. Millar, Transactions Illg. Eng. Society, 1916, Vol. XI, page 479.

value derived from the investigation was the conviction reached by practically all participants that it is very important, in formulating ideas concerning street lighting, to carry out studies of street lighting in the street at night under practical working conditions. Studies in the laboratory are most valuable when co-ordinated with corresponding studies under actual street-lighting conditions. Studies made in the office cannot be relied upon to indicate correct conclusions unless the conclusions are borne out by experience in the street.

The foregoing will indicate the standpoint from which the following discussion is approached:

COMMERCIAL CONSIDERATIONS.

The great bulk of street lighting in this country is performed by public utility companies under contract with municipalities. This is the only class of service in which such companies come into touch with the entire community and in which they serve the entire populace. Furthermore, it is the only class of service which affords the public at large continuous opportunity to judge of the corporation's service standards. The conditions, therefore, are such as to afford every incentive to the company to supply the best possible service upon the best possible terms to the municipality. Public utility corporations are usually content to accept a very modest profit on their investment for public street lighting, and are usually keenly alert to opportunities for improving their service as rapidly as the progress of the art permits. It has been the writer's experience that the best street illumination is provided in cities in which the municipality and the public service corporation co-operate on good terms in making available to the public the best possible street-lighting service at the lowest practicable rates. In case either the public utility corporation or the municipality fails to manifest a progressive attitude, or to co-operate for the best development of the street-lighting system, the service suffers. Observation indicates that best results are had when the municipality directs its efforts toward getting the best possible service rather than toward reducing the rates to the lowest possible terms. There is something wrong with the municipality which fails to elicit the best efforts of the public utility company operating within its confines, and there is



Fig. 1. Post used on Market St., San Francisco.



Fig. 2. Post used in Philadelphia.

something wrong with the utility which will not do its utmost to provide a pleasing, attractive, reliable and effective street-lighting service.

SERVICE STANDARDS.

Service is coming to be recognized as the leading factor in street lighting. The maintenance of lamps, fixtures, posts and lines in good and attractive condition, the reduction of outages to a minimum, the quick re-establishment of service after failure—these count heavily, whatever the other engineering or commercial features of the situation may be.

Every municipality and public utility does well to promote civic pride by adopting attractive street-lighting posts and fixtures. Such equipment evidences a measure of municipal self-respect which cannot fail unconsciously to impress both citizen and visitor. The cost of the installation of such fixtures and posts may be distributed over so many years as to make the yearly cost-increment negligibly small, when it is considered that equipments such as are illustrated in the accompanying cuts are made available. Figs. 1, 2, 3, 4.

FAR-SIGHTED PLANNING IN STREET LIGHTING.

The history of street lighting in this country divides itself rather naturally into four stages, as follows: Early street lighting with open carbon arc lamps, 1888-1893; extension of street lighting with inclosed carbon arc lamps which largely replaced the open carbon arc lamps, 1894-1904; further extension of street lighting with magnetite lamps and replacement of many open and inclosed carbon arc lamps, 1904 to date; further extension of street lighting with Mazda C lamps and further replacement of open and inclosed carbon arc lamps, 1914 to date. Thus it is apparent that something like once each decade a new illuminant has made its appearance, which has given a new impetus to street lighting and has resulted in discarding older and less effective illuminants. Not only have there been changes in illuminants, but also styles and practices in fixtures, methods of mounting, posts, etc., have undergone change. These changes have introduced a difficult problem into municipal engineering, and only far-sighted planning has made it possible for municipalities to absorb the changes while continuing the extension



Fig. 3. Post used on Fifth Ave., New York City.

and expansion of a general system of lighting with maintained satisfaction to all concerned. In municipalities where the street lighting has been developed after a definite and far-sighted plan, new illuminants have expedited the growth of the lighting system and the consummation of the plan. In municipalities where such far-sighted planning has been lacking, the result has been confusion, growth in a number of directions, with ultimate dissatisfaction, which occasionally has led to the scrapping of all existing street-lighting equipment and the substitution of an entirely new system at the expense of the public. In such cases the public is called upon to pay for the incompetence of officials having this part of public service in charge.

STREET ILLUMINANTS.

Street illuminants which are being installed at this time in greatest numbers are, first, Mazda C lamps, and second, magnetite arc lamps. The relative light-producing and electrical values for these lamps are presented in Table I, which is based upon tests made public by the Lamp Committee of the Association of Edison Illuminating Companies.

The Mazda lamps of both series and multiple types now perform in an eminently satisfactory manner, tho their candle-power and watts ratings are not as reliable as is desirable. The considerable variety in which they are procurable, both as to type and size, makes them available for practically any lighting system, excepting only that their operation in series with arc lamps is not regarded as approved practice. The flexibility thus offered is one of the most attractive features of the Mazda street-lighting system. The more powerful of the magnetite lamps attain higher light-producing efficiencies than does the Mazda lamp. Costs vary with local conditions, but in a general way it is understood that the investment costs are greater for the magnetite system than for the Mazda system, while total costs in the long run are of the same order. The magnetite lamp produces a whiter light than does the Mazda lamp, which is regarded by some as preferable for street-lighting purposes.

ACCESSORIES.

The equipment of street lamps, whether Mazda, magnetite or



Fig. 4. Post used in Rochester, N. Y.

older illuminants, is recognized as being of great importance to the success of the street illumination. Diffusing globes of one form or another, which reduce the brightness of the source and improve the appearance of the fixture, are regarded as desirable in city streets, while reflectors which direct below the horizontal light that would otherwise pass into the upper hemisphere, are generally employed in suburban and residential streets. Buildings on important streets should be lighted if the street is to prove attractive by night. This constitutes an added requirement for diffusing globes, and offers one reason for the elimination from urban streets of those forms of accessories which direct all the light below the horizontal. If glare is to be avoided, the power and brightness of the light source at angles at which it is viewed must be kept within reasonable limits, especially if the surfaces in the region of the light source are not well lighted. This is accomplished by the use of a diffusing globe and to some extent by the use of standard forms of reflectors. While the latter do not reduce the brightness of the source itself, yet they add a brightly lighted surface of larger area which is close to the source and which reduces its glare. One reason why the exposed arc of the magnetite lamp in the standard pendant form is not a more serious source of glare is that it is immediately surrounded by the reflector which is built into the lamp, offering a larger bright surface immediately adjacent to the arc itself. The variety of diffusing globes has been increased recently by the addition of glassware which is shaped to conform to the design of the fixture with which it is used, or to distribute the light after a desired manner. Also segmented diffusing globes have been employed with considerable success. The construction of a skeleton frame with diffusing glass panels, while likely to increase the cost, yet offers a means of providing artistic fixtures, which is a much appreciated addition to the forms of fixtures earlier available.

A recently developed accessory for street lighting is the prismatic refractor. This is a clever adaptation of prismatic glassware which offers a simple and flexible means of re-directing the light. Thus far, however, it has not proven notably successful. Aside from the added cost which the employment of such a device necessitates, the refractor thus far has been produced in small sizes. These inclose powerful light sources and direct large proportions of the light at angles which are well within the visible region. The result is a con-

dition of glare which both reduces visibility and occasions discomfort. This weighs heavily against the advantageous light-directing qualities of the device.

ILLUMINATING DESIGN.

The subject of lamp-spacing intervals, mounting heights and lamp locations continues to receive attention. To a peculiar degree this is contingent upon local conditions. It is evident, as a result of experience, that the best possible way to design a street-lighting installation for a particular kind of street is to experiment on such a street. Fig. 5 illustrates a trial installation of this sort in the city of New York.



Fig. 5. Illustrating **empire method** of locating lamps as employed in New York City.

Lamp posts were mounted in rock-ballasted barrels and upon variable-height posts with variable-length extension arms, and were connected to the electrical circuits by temporary cables laid upon the street surface. These portable lighting units were then moved about the street until the engineer in charge was satisfied that the best location for the lamps had been attained. Also, such trials as it was desired to make of different lighting accessories were made in the same connection. The result is that the lighting so designed is notable for the effective employment of the materials at hand. It may be seen upon upper Broadway and upper Seventh avenue, New York City.

The literature of street lighting will be found to contain discussions of mounting height, spacing interval, etc., each prepared from a particular point of view. Thus an article may be devoted to the determination of the best design to secure uniform horizontal illumination with particular light sources, another to the best location of lamps in order to avoid the injurious effects of glare. Very little is available, however, which may be taken as a sure guide to the design of street lighting with a view to securing greatest effectiveness or to serving to best advantage the major purposes of street lighting as laid down in the beginning of this article. The investigations of the Joint Street-Lighting Committee which have been referred to were not sufficiently comprehensive to indicate the facts regarding these matters for the generality of cases; they showed the best conditions in a particular street with particular types of illuminants employed. They went far enough, however, to show that neither uniformity of horizontal illumination on the street nor avoidance of glare in themselves can be taken as an indication of effective street lighting. These are factors which, to a reasonable degree, should influence street-lighting design, but neither is the governing factor to be applied irrespective of other considerations; and, be it noted, often one may be found in conflict with the other, rendering necessary a compromise between the two.

Some of the conclusions which the writer has reached as a result of the investigation referred to, and of other recent studies with which he has been associated, are as follows: Where street-lighting design has been undertaken intelligently by competent engineers the illuminating results are likely to be reasonably good. Manufacturers of illuminants have been influential in promoting the right use of their products and operating engineers have profited by their observation to avail themselves of opportunities to make the most of materials at their disposal. In matters of mounting-height, lamp-spacing and lamp-location these statements have been found to apply. Take, for example, lamp-spacing. Operating engineers have doubtless wished to employ more lamps in instances where appropriations have made it necessary to install no more than one per 300 or 500 feet. Street lighting so provided has been referred to at different times as a joke at the public expense and an absurdity not to be referred to as street lighting. Yet the value of such lighting need hardly be asserted. So useful is it that lamps spaced at 1,000-

foot intervals have been found, in the lighting of interurban highways, to be of great utility when judiciously located. As cities grow, lamps are located at shorter intervals, and on important streets they are brought close together. Under these conditions street lighting is vastly improved, but, considering the latest knowledge of street-lighting effectiveness, one should be slow to condemn as useless street lighting which suffers from inadequacy of lamps and from too great spacing intervals. Such criticisms would cease to be heard if the critics could be made to live for a short time in one of the towns which suffers under a moonlight schedule and were to find themselves compelled to use streets which have no artificial lighting and which are deprived of moonlight by clouds. Under such conditions even very infrequent spacing of the artificial illuminants proves such a boon to the wayfarer that he could not be convinced that such lighting lacks utility. Wide spacing intervals are regarded as objectionable because of the dark areas between lamps or the excessive non-uniformity of the lighting. These are truly objectionable, but endeavors to measure the visibility of objects on the street and the irregularities of the street surface with such lighting have made it clear that such non-uniform lighting is not nearly as objectionable as it has been considered to be. Efforts to fill in the dark midway regions between lamps by altering the distribution of light without decreasing lamp spacing have accomplished much less than has been expected of them; only by installing additional lamps can this be remedied successfully.

The lesson which this contains appears to be that where street lighting is inadequate and inefficient because of wide spacing, more lamps ought to be employed in order to decrease the spacing intervals. Where, however, the street is unlighted, so much improvement can be effected by lighting it even inadequately with lamps spaced at large intervals that there should be no hesitancy to install such a system on the ground that it is useless.

Recent studies have made it clear that uniform street lighting is sometimes objectionable in itself. Usually uniform lighting is obtained by placing many light sources close together. There is then so much light available that some diminished efficiency per unit of light passes unnoticed. When, however, an effort is made to deter-

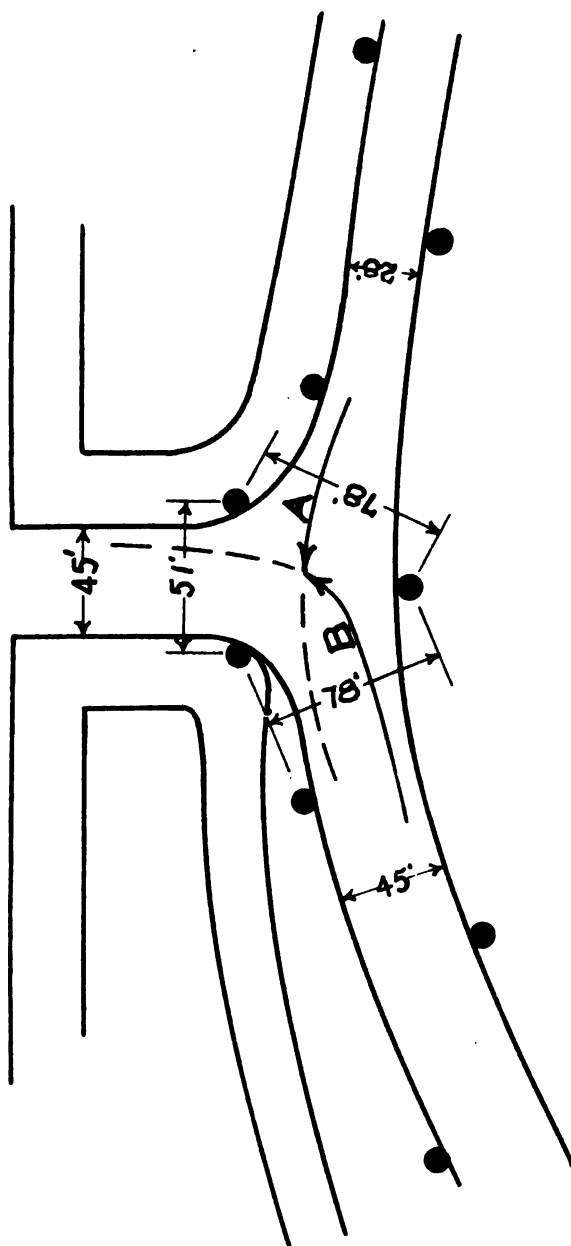


Fig. 6. Dots indicate locations of lamps which produce multi-directional illumination of low effectiveness.

mine the specific effectiveness of such lighting, its inherent weakness is revealed. Fig. 6 is a plan of entrance to a park.

Park drives branch north and south from the entrance. One-hundred-candle-power lamps are located 11 feet above the street level at the positions indicated. The writer witnessed an accident at this point which he believes to have been due to the uniform illumination which prevailed. A carriage drawn by a bay horse, passing from the north to the south drive across the park entrance, was struck by an automobile which was moving toward the entrance from the south drive. From a position about 100 feet behind this automobile three observers failed to see the carriage. The carriage and horse were of more or less the same light-reflecting quality as the street surface and the surroundings in general. The street and the vehicle were illuminated by three or more lamps, the light being received from as many directions. Ordinarily the street at this point would be regarded as well illuminated, since horizontal illumination intensities are of the order of 0.045 foot-candle and the illumination is fairly uniform; yet this accident seems attributable to ineffective street lighting. It has been shown in the street-lighting studies referred to that uniformity of illumination obtained by a multiplicity of light sources is ineffective because light from a variety of directions diminishes contrasts. Most visibility at night in the streets is dependent upon shade contrasts. With light received from one direction, shade contrasts and shadows are strong and objects are clearly revealed. Moonlight is regarded as being excellent night illumination, and its excellence is sometimes mistakenly attributed solely to the uniformity of the illumination. It is to be noted that while the illumination is uniform, yet it is derived from a single source, and contrasts are therefore strong and objects are clearly defined. If we could conceive of natural illumination of intensity equal to that of moonlight, but derived from numerous stars, we would have a condition of ineffective uniform illumination. It is to be concluded, therefore, that the use of many small light sources, closely spaced, especially if staggered and mounted over both curbs, is undesirable, not only because such an installation is costly, but also because the illumination is relatively ineffective, since it provides a low-contrast uniformity. On the other hand, illumination from very powerful light sources at very great intervals is objectionable because the street lighting suffers from exten-

TABLE I. RELATIVE LIGHT-PRODUCING EFFICIENCIES OF MAZDA C AND MAGNETITE LAMPS.

Mazda C Lamps					Magnetite Lamps				
Description	Total Lumens	Bare Lamp			Description	Amp.	Electrode	Globe	Equipped for service
		Average Watts	Lumens per Watt	Total Lumens					
6.6-amp., "60-cp.".....	600	46.9	12.8	46.9	9.6				
6.6-amp., "100-cp.".....	1,000	71.9	13.9	71.9	10.4				
6.6-amp., "250-cp.".....	2,500	151.0	16.12	1,875	12.1				
6.6-amp., "400-cp.".....	4,000	246.0	16.32	3,000	12.3	4	Standard	Clear	2,991 410 9.65
6.6-amp., "600-cp.".....	6,000	367.0	16.32	4,500	12.3	4	High Efficiency	Clear	4,649 323 14.4
20-amp., "600-cp.".....	6,000	310.0	19.3	4,500	14.5	5	Standard	Clear	5,768 390 14.8
20-amp., "1,000-cp.".....	10,000	513.0	19.3	7,500	14.5	5	High Efficiency	Clear	7,656 371 20.6
110-volt, "75 watts".....	865	75.0	11.5	649	8.7	6.6	Standard	Clear	8,708 511 17.0
110-volt, "200 watts".....	2,795	200.0	13.97	2,098	10.5				
110-volt, "400 watts".....	6,150	400.0	15.38	4,620	11.5				
110-volt, "750 watts".....	12,800	750.0	17.06	9,600	12.8				
110-volt, "1,000 watts".....	18,000	1,000.0	18.00	13,500	13.5				

*Compensator.

TABLE II. SOME NOTABLE STREET-LIGHTING INSTALLATIONS.

City	Name	Street		Curbs	Width in feet	Lamps		Type	Size	Accessory	No. per Mile
		Class	Bldg. Lines			Multiple	Size				
New York	Fifth Avenue	Business	99	55		Multiple Mazda C	400 watts		Diffusing globe		118*
Baltimore	Baltimore Poca Jones Falls	Business	65	40		Ornamental magnetite	6.6 amp.		Diffusing globe		143
Pittsburgh	Fifth Avenue	Business		36		Ornamental magnetite	6.6 amp.		Diffusing globe		132
Washington	Penn. Ave.	Business	160	109		Ornamental magnetite	6.6 amp.		Diffusing globe		104
Rochester	Main Street	Business	90	45		Ornamental magnetite	6.6 amp.		Diffusing globe		104
Hartford	Main Street	Business	80	50		Mazda C	600 cp.		Diffusing globe		94*
Washington	Sixteenth St.	Residence	80	50		Mazda C	80 cp.		Diffusing globe		88
Rochester	Lake Avenue	Residence	50	50		Mazda C	1,000 cp.		Diffusing globe		27
New York	Upper 7th Ave.	Apartment	150**	80		Multiple Mazda C	400 watts		Diffusing globe		59

*Twin lamp posts. **Center parkway.

sive dark areas between lamps which are almost unlighted. In street lighting, moderation is to be practiced everywhere. Sources of moderate power, mounted at moderate heights, producing a moderate diversity of illumination intensity along the street, are likely to prove most effective.

CONCLUSION.

Summing up, therefore, it is the writer's belief that improvement in municipal street lighting is to be had thru the promotion of good relations between the municipality and the local public service corporation; thru the pursuit of a definite, far-sighted plan of street-lighting development; thru the utilization of latest and most efficient light sources with approved accessories and pleasing mounts; thru the installation of lamps in accordance with the experience obtained in trial installations, and thru following methods of moderation which are free from fads and fancies.

Latest materials of illumination and latest theories of street lighting are to be found embodied in the most recent street lighting installations. It is by studying these that one is able to estimate the value of the new appliances and the new ideas which have been discussed in the foregoing paragraphs. The installations which should be considered in this connection are notably those described in the accompanying Table II, where the principal features are set forth with approximate accuracy.

PASADENA'S ELECTRIC UTILITY AND STREET LIGHTING SYSTEM.

A REVIEW OF NINE YEARS' EXPERIENCE.

By C. Wellington Koiner, E. E., General Manager, Municipal Lighting Department.

Before the city of Pasadena owned its light and power plant, the people paid a private corporation a maximum rate of 15 cents per kw. hr. for electrical energy for lighting purposes. Just before the city built, the price was dropped to 12½ cents for the first 666 kw. hr. consumed in one month less 10 per cent for prompt payment. The service rendered for street lighting was very poor indeed; in fact, it was so poor and deficient that the company was not able to collect for some of it.

The prime reasons for the city's entering into the light and power business were:

First, to improve the service.

Second, to obtain a good service at a reasonable rate.

The first rate established for illumination was a maximum of eight cents and afterwards the rate was reduced and, at the present time, the following rates prevail:

INCANDESCENT LIGHTING.

"Class A"—The first 100 kilowatt hours, or less, of energy furnished in any one month to any consumer, five cents per kilowatt hour.

"Class B"—The kilowatt hours of energy furnished in any one month to any consumer in excess of 100 kilowatt hours and not exceeding 500 kilowatt hours, 4½ cents per kilowatt hour.

"Class C"—The kilowatt hours of energy furnished in any one month to any consumer in excess of 500 kilowatt hours and not exceeding 1,000 kilowatt hours, 4 cents per kilowatt hour.

"Class D"—The kilowatt hours of energy furnished in any one month to any consumer in excess of 1,000 kilowatt hours and not exceeding 2,000 kilowatt hours, 3½ cents per kilowatt hour.



Types of Pasadena Bridge Lighting. Lower one is the Colorado St. Bridge.

"Class E"—The kilowatt hours of energy furnished in any one month to any consumer over 2,000 kilowatt hours, 3 cents per kilowatt hour.

A minimum monthly charge of 50 cents per meter of three kilowatt capacity or less, and 30 cents for each additional kilowatt of meter capacity required, shall be made for each meter.

Gem lamps are furnished free for renewal purposes and the best quality of Mazda lamps are sold at cost to the customers of the department.

POWER.

"Class A"—The first 100 kilowatt hours of energy or less, furnished in any one month to any consumer, 4 cents per kilowatt hour.

"Class B"—The kilowatt hours of energy furnished in any one month to any consumer in excess of 100 kilowatt hours and not exceeding 300 kilowatt hours, 2.4 cents per kilowatt hour.

"Class C"—The kilowatt hours of energy furnished in any one month to any consumer in excess of 300 kilowatt hours and not exceeding 500 kilowatt hours, 2.4 cents per kilowatt hour.

"Class D"—The kilowatt hours of energy furnished in any one month to any consumer in excess of 500 kilowatt hours and not exceeding 1,000 kilowatt hours, 2 cents per kilowatt hour.

"Class E"—The kilowatt hours of energy furnished in any one month to any consumer in excess of 1,000 kilowatt hours and not exceeding 1,500 kilowatt hours, 2 cents per kilowatt hour.

"Class F"—The kilowatt hours of energy furnished in any one month to any consumer in excess of 1,500 kilowatt hours and not exceeding 2,000 kilowatt hours, 1.9 cents per kilowatt hour.

"Class G"—The kilowatt hours of energy furnished in any one month to any consumer in excess of 2,000 kilowatt hours and not exceeding 3,000 kilowatt hours, 1.8 cents per kilowatt hour.

"Class H"—The kilowatt hours of energy furnished in any one month to any consumer over 3,000 kilowatt hours, 1.2 cents per kilowatt hour.

A monthly minimum charge will be collected for electrical energy of \$1.00 per meter of $1\frac{1}{2}$ kilowatt capacity or less and 75 cents for each additional kilowatt of meter capacity required.

Ornamental street lighting is charged for at the rate of 3 and $3\frac{1}{2}$ cents per kilowatt hour.

The accompanying tables, I and II, give a summary of nine years' operation.

	1906-07	1907-08	1908-09	1909-10	1910-11	1911-12	1912-13	1913-14	1914-15	1915-16
Receipts	\$23,425.64	\$46,876.76	\$74,935.32	\$110,011.10	\$123,485.11	\$138,889.41	\$176,431.30	\$193,866.79	\$214,292.51	\$214,292.51
Net profit from sale of electrical appli- cances, etc. ....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Operating expenses.. \$	997.09	17,688.71	21,431.73	36,068.56	56,570.95	63,700.30	70,073.45	96,641.66	100,946.34	107,037.09
Interest .....	.....	8,771.92	11,454.47	14,909.24	18,387.79	21,637.37	20,728.54	23,020.47	24,968.50	26,816.40
Depreciation	4,466.62*	9,490.64	11,728.07	15,817.05	17,902.69	19,538.66	24,529.33	27,408.25	30,345.04	41,740.67
Surplus .....	.....	.....	1,361.49	8,140.47	17,149.67	18,628.78	23,558.09	29,360.92	37,246.23	39,351.11
Deficit	5,463.71	12,525.63	.....	.....	.....	.....	.....	.....	.....	.....
Total surplus to date	\$23,425.64	\$45,375.76	\$74,935.32	\$110,011.10	\$123,485.11	\$138,889.41	\$176,431.30	\$193,866.11	\$214,735.27	\$214,735.27
Less emergency claim paid, charged to surplus	.....	.....	.....	.....	.....	.....	\$166,707.42	9,000.00	.....	.....

* This depreciation covers period during construction of the plant, 1906-07, and is premature. However, it goes to offset the changing of 60-cycle generators to 50-cycle, which change was made during the year 1910.

ASSETS		LIABILITIES	
PROPERTY ACCOUNT	\$638,620.61	FUNDED INDEBTEDNESS	\$258,800.00
Real estate, station equipment, over- head and underground lines, trans- formers, meters, etc.....	\$840,434.44	Total bonds issued.....	\$327,000.00
Less depreciation reserve to June 30, 1916	201,813.83	1902 4%	\$ 2,000.00
		1906 4%	125,000.00
		1908 4%	50,000.00
		1909 4%	150,000.00
Total depreciation reserve to June 30, 1916	\$202,957.02	Less bonds redeemed.....	68,200.00
Less replacements 1915-16	1,143.19	Paid out of taxes.....	60,075.00
		Paid out of operating surplus	8,125.00
Net depreciation reserve	\$201,813.83		

PREMIUM ON BONDS ...	3,886.43
CONTRIBUTION FROM	
TAXES	223,603.56
Taxes of year 1906	52,382.35
Street lighting appropria- tion	2,299.95
Land for power plant buildings	6,000.00
Land for Pearl St. ware- house	1,900.00
Bonds redeemed	60,075.00
Bond interest paid	86,996.26
Loan from general fund..	40,000.00
Less amount repaid....	26,000.00
	14,000.00
Balance carried down	\$486,239.99
	152,380.62
	<u>\$638,620.61</u>
ACCOUNTS PAYABLE and DEPOSITS	\$ 245.62
RESERVE FOR INTEREST	70,669.59
Charged on total aver. in- vestment	170,434.70
Paid bond interest from taxes	86,996.26
Paid bond interest from surplus	12,818.75
SURPLUS	99,815.01
Balance of account July 1, 1915	147,707.42
Gain for year ending June 30, 1916	108,356.31
Actual operating gain..	39,351.11
Less increase in interest reserve	55,082.26
	15,732.15
	<u>\$218,622.73</u>
Balance from capital account.....	\$152,380.62
INVENTORIES	25,909.37
ACCOUNTS RECEIVABLE	20,567.32
Commercial light and power.....	\$ 14,501.60
City streets and buildings.....	5,014.89
Sundry accounts	1,050.83
CASH	19,765.42
Municipal lighting fund	19,465.42
Office cash	300.00
	<u>\$218,622.73</u>

The balance sheet preceding shows the result of the nine years' operation.

During the nine years of operation and construction, there has been a continuous fight with the city's competitor. The corporation in competition with the city of Pasadena serves about nineteen or twenty other cities, including a part of Los Angeles and, but for this, they could not compete with the city plant. Pasadena has in the past on several occasions offered to purchase the distributing system of its competitor but it has always refused to sell. Our neighboring cities, except the city of Los Angeles, pay this company a rate 40 per cent more than the municipal plant charges Pasadenans.

The rate payers of Pasadena have saved in their pockets approximately \$1,079,083.96 since the installation of their municipal plant, by reason of the difference in rates charged the neighboring cities, except Los Angeles, and the rates charged by the municipal lighting department of Pasadena. The people still have their plant intact and in operation and the saving in their pocket. They have a high class service and one of the most favorable rates in the country.

Table III shows the distribution of electrical energy for the year ending June 30, 1916.

A summary of the operation of the department for the year ending June 30, 1916, is given in Table IV.

TABLE III. OUTPUT REPORT IN KW. HR. FOR THE YEAR ENDING JUNE 30, 1916.

	Output	Receipts	Receipts Per kw. hr.
<i>Street Lighting</i>			
Clusters and alleys	469,230	\$16,527.86	.03522
Arcs and series tungstens	853,190	37,512.11	.04397
	1,322,420	\$54,039.97	.04086
<i>Commercial System</i>			
Lighting, including city departments..	2,512,279	124,248.56	.04946
Power, including city departments....	1,580,907	36,003.98	.02277
	4,093,186	\$160,252.54	.03915
Total current sold	5,415,606	\$214,292.51	.03957
Lighting at plant	36,009		
Lighting at office and storeroom.....	18,249		
	54,258		
Core loss of transformers.....	484,548		
Shunt loss of meters.....	145,418		
Testing	8,750		
Copper and transmission losses and un-			

accounted for losses	658,920					
	1,297,636					
Total current generated	6,767,500					
Received for all current generated.....						.03166
Received for all current sold.....						.03957
	Prod.	Dist.	Gen.	Int.	Dep.	Total
Cost of all current generated..	.00675	.00456	.00451	.00393	.00617	.02592
Cost of all current sold.....	.00844	.00569	.00563	.00491	.00771	.03238
Efficiency of distributing system						80.95%
Load factor						34.63%
Capacity factor						25.68%
Revenue per kw. station capacity (boilers).....						\$71.43
Maximum demand						2225

TABLE IV. REPORT OF MUNICIPAL LIGHTING WORKS DEPARTMENT FOR YEAR ENDING JUNE 30, 1916.

	1915-16	1914-15
Receipts and charges	\$214,292.51	\$198,366.79
Expenditures	107,027.09	100,946.34
Balance for bonds, interest, depreciation and profit	\$107,265.42	\$ 92,421.45
Interest on 1912 issue of bonds for year.....	\$ 53.00	\$ 55.00
Interest on 1906 issue of bonds for year.....	3,875.00	4,000.00
Interest on 1908 issue of bonds for year.....	1,856.25	1,898.44
Interest on 1909 issue of bonds for year.....	5,100.00	5,200.00
One bond retired, 1902 issue.....	50.00	50.00
One bond retired, 1906 issue.....	3,125.00	3,125.00
One bond retired, 1908 issue.....	1,250.00	1,250.00
One bond retired, 1909 issue.....	3,750.00	3,750.00
	\$ 19,059.25	\$ 19,328.44
Amount applicable for interest reserve, depreciation and construction	88,206.17	78,093.01
	\$107,265.42	\$ 92,421.45
Output kw. hr.	6,767,500	5,866,358
Kw. hr. per bbl. oil.....	141.81	134.26
Production cost of current generated.....	.00675	.00763
Production cost of current sold.....	.00844	.00952
Distribution cost of current sold.....	.01132	.01196
Interest cost of current sold.....	.00491	.00531
Depreciation cost of current sold.....	.00771	.00646
Total cost of current sold.....	.03238	.03325
Operating expenses, 49.94% of gross income.		
Meters in operation July 1st, each year.....	8829	7755
Average number of meters in operation during the year	8288	7326
Efficiency of distributing system.....		80.95%

STREET LIGHTING.

By owning its own plant, the city has found it to be a great advantage, especially at such times as it is desired to change or rearrange or adopt modern street lighting equipment.



**Ornamental Street Lighting Systems in Pasadena. Marengo Ave.,
Orange Grove Ave., Hillcrest Ave., Oak Knoll.**

The city has been able to eliminate inefficient street lighting units at pleasure, adopting the latest type of gas-filled units in place of arc lamps, also installing ornamental systems on various streets and removing the overhead fixtures, making all changes to conform to the new system or systems as required, without having any controversy about the change.

The city has approximately 165 miles of streets and alleys, all of which are illuminated. The candle-power supplied for street lighting at the beginning of the operation of the municipal plant was 51,000 while that supplied at the present time is 538,852, showing that the city lighting has increased approximately 956 per cent since the municipal plant began to supply the street lights while the mileage of streets has increased only 10 per cent. It is calculated that the city streets are as well illuminated as any American city without exceptions.

The following units are in service:

1774	80-c.p. Mazda lamps.
23	100-c.p. Mazda lamps.
46	250-c.p. Mazda lamps.
81	400-c.p. Mazda lamps.
145	600-c.p. Mazda lamps.
1	1000-c.p. Mazda lamp.
6	40-watt red signal lights.
41	60-watt alley lights.
3	100-watt alley lights.
152	5-light ornamental posts equipped with four 40-watt and one 100-watt lamps.
42	5-light ornamental posts equipped with four 40 and one 60-watt lamps.
8	13-light ornamental posts equipped with one 40-watt and twelve 25-watt lamps.
181	ornamental posts equipped with one 600-c.p. lamp.
54	ornamental posts equipped with one 400-c.p. lamp.
420	ornamental posts equipped with one 80-c.p. lamp.
9	ornamental posts equipped with one 60-c.p. lamp.
536	ornamental posts equipped with one 60-watt lamp.
363	ornamental posts equipped with one 100-watt lamp.

STREET LIGHTING RATES.

80-c.p. Mazdas	\$12.00 per annum
125-c.p. Mazdas	15.00 per annum
400-c.p. Mazdas	48.00 per annum
600-c.p. Mazdas	60.00 per annum
Cluster posts, 3c to 3½c per kw. hr.	
The average rate received for all street lighting for the past year was	4.086c per kw. hr.
While the average rate received for commercial and residence lighting was	4.946c per kw. hr.

The city has standardized its ornamental street lighting systems, specifying the height of the post, the spacing, the size of lamp and the size of globe that is to be used on residence and business streets. It was early found that the one-light standard was thought



Lighting of Madison Ave., Pasadena, Calif.

to be the proper thing for the city, therefore, there are only two streets having more than one light per post.

The reason for adopting the one-light standard is that it does not appear to commercialize a residence street. One globe and lamp can be maintained more efficiently than the ordinary three or five-light fixture is maintained in the average city, consequently, it is better to put all of the time on one globe, keeping it in first class condition, than to multiply it and not have proper care; or to find after installation that the three or five-light fixture is too expensive to operate and then substitute smaller lamps, cutting down the illumination.

The city has adopted the series system using 6.6-ampere 80-candle power gas-filled lamps on the residence streets. The posts are spaced 75 feet apart staggered. The height of the post ranges from 10 feet, 6 inches to 11 feet, 6 inches, and the globe used is 16 or 18 inches in diameter with 8-inch holder. The wire is run in conduit in parkway, there being two circuits, one for cutting out every other light at 11 o'clock and the other circuit for carrying the balance of the lights all night.

On the business streets or in the center of the city there has been adopted what is known as the Novalux type or its equivalent, mounted on posts 12 feet to 13 feet, 6 inches high. The lamps are 400 to 600-candle power and are wired up in the same manner as on residence streets; approximately half of them going out at mid-



**Business Street Lighting on Raymond Ave., Pasadena, Calif.
Novalux Lamps.**

night, leaving a sufficient number to give more light than the city formerly had, even after half of the ornamentals are out.

With the installation of ornamental lights there is always an increased illumination and a better distribution as compared with the lights of the old systems.

The method of installing ornamental lights on the city streets is that the property owners in any thoroughfare that it is desired to improve petition for the improvement and the cost of the new system is paid for by the abutting property owners. The property owners always have the privilege of selecting any type of post they may desire, hence, the city has a variety of ornamental lighting posts, concrete, copper clad, cast iron and bronze, ranging in price from \$18 to \$115 per post before installation and without equipment. The average cost in the residence section is from 60 cents to 80 cents per property front foot. The average cost for the higher candle-power lamps used in the business section, is in the neighborhood of \$1.30 to \$1.40 per property front foot. The material and equipment used are the very best. We could use cheaper material and

we have installed a few isolated systems as low as 35 cents per property front foot. However, after comparing the cheaper systems with the systems installed at the present time, no one would think of installing anything but the very best, not only in quality but in appearance.

The city has adopted the plan of numbering the globes on all streets to correspond to the house or lot number. It is found to be of great advantage in locating a number at night. The street names are also placed on the globes at street intersections. The letters used are 1½ and 2 inches high and the numbers 1½-inch, placed half way between the center and the bottom of the globe. This size letter and number is found to be not unsightly or to in any way disfigure the globe. It has been found necessary to cover the lettering with a solution of celluloid in order to prevent the deterioration of the lettering and numbering.

The city has installed at the present time 1,765 ornamental lighting posts along 20.31 miles of streets.

The balance of the city is illuminated in the usual way with fixtures suspended from poles, mast arms and overhead.

The current for all ornamental lighting is paid for by the city just the same as is all other street lighting. It is the practice in some cities to charge the abutting property owners for a portion of the current consumed after ornamental lighting installations are put in, however, Pasadena is seeking to encourage the installation of an ornamental system that will ultimately cover the city.

A PROPOSED STANDARD FORM FOR MAKING TRAFFIC COUNTS.

BEING THE REPORT OF THE TRAFFIC COMMITTEE OF THE AMERICAN SOCIETY OF MUNICIPAL IMPROVEMENTS, BASED ON INFORMATION GATHERED FROM ALL PRINCIPAL CITIES ON PRESENT METHODS OF MAKING TRAFFIC COUNTS, AND SUGGESTING A STANDARD FORM, WHICH IS SIMPLE, ECONOMICAL AND COMPLETE AND WILL FACILITATE FQUITABLE COMPARISONS BETWEEN COUNTS MADE IN VARIOUS CITIES.

J. C. Hallock, Chairman, Assistant Chief Engineer, Newark, N. J.

Previous reports of your Traffic Committee have dealt interestingly with various phases of the traffic question, a matter which will assume increasing importance as the traffic in cities increases and the resultant problems are multiplied. For this reason the report of the Traffic Committee for the current year is confined to the single and fundamental consideration of means of taking a traffic census.

Response to inquiries sent to the twenty largest cities of the United States disclosed that in but seven of these have traffic counts been made. Where "traffic counts" are mentioned in this report, reference is made only to enumeration of character and number of horse-drawn vehicles, motor-driven vehicles and street cars using the public highways or streets.

While a more extended canvass of cities could have been made, it was believed that the most complete and useful information could be had in the larger cities where traffic problems are most acute. Of the cities where inquiry was made, the following reported having made some form of traffic counts:

Baltimore, Buffalo, Chicago, Newark, New York (Boros of Brooklyn and Manhattan), Philadelphia, St. Louis, San Francisco.

The following cities reported having made no traffic counts:

Cleveland, Denver, Detroit, Kansas City, Los Angeles, Milwaukee, Minneapolis, New Orleans.

It is quite possible the inquiry addressed to the latter cities did not come to the attention of those in charge of making such counts, tho the majority are known to have made no such counts. No reply was received from Boston, New Orleans, Seattle, Washington.

Curiously enough, cities which have made traffic counts primarily have had different reasons for so doing. Counts, consequently, have been made in different manner and at varying intervals with variation of duration and thoroughness. Some of the purposes for which counts have been made are:

Traffic regulation, street cleaning purposes, street planning or replanning, paving design, durability and maintenance, fixing tax values.

Complete and usable traffic counts will be of increasing usefulness to those in charge of each branch of municipal activity above mentioned. Traffic counts cannot alone suffice to determine the character of traffic regulation, the amount of street cleaning necessary, the design of pavement or the fixing of tax values, but their presence will greatly aid in a more accurate handling of these problems.

The first essential in making a traffic census is simplicity of form, so that one enumerator can count the greatest amount of traffic with the greatest accuracy and with the least difficulty. A second essential is that the field notes may easily be transposed into the forms desired by the several departments which may have occasion to make use of them. When complicated checking devices are used to make the count, or when final figures are recorded on the field sheets, an extra amount of labor is necessitated, but one final form of usefulness is obtained, and the highest degree of accuracy may be sacrificed.

It makes little difference what the prime incentive may be, traffic counts can as well be made to serve one purpose as another when properly taken. A standard form is most desirable, not only for the sake of efficiency, but in the opportunity which would result from comparisons with conditions in other cities and, what is still more desirable, a simple means of comparison of counts taken at various intervals. A standard form could be used irrespective of the number of counts made, their durability or purpose, since a

certain classification of all vehicles can be made, subject to some slight modification as time and custom may demand, which classification would suffice to meet all conditions. While some change will be necessary from time to time in the scale of vehicular weights, particularly of motor trucks, the scale of weights can well be made to meet conditions without modifying the classification. An interesting conclusion in this connection is contained in a paper on "The Automobile and the City Plan," by Nelson P. Lewis, that "The popularity of the 3½-ton and the 5-ton truck is quite noticeable. Six of the largest makers of motor trucks, one organization dealing with the technical problems of their design and one devoting itself to the promotion of their use, have expressed their opinions as to the probable economic limits of weight of car, load capacity and load on rear axle. The maximum weight of car is estimated at from 10,000 to 12,000 lbs., the load capacity at from 10,000 to 16,000 lbs., and the load carried on the rear axle at from 16,750 to 24,000 lbs. The load per inch width tire is estimated at from 600 to 800 lbs., and most of them note that this limit is due to the inability of rubber tires to sustain a heavier load, while none of them appears to have considered the effect of concentrated loads upon street pavements."

While some slight differences occur in the classification of vehicles, that which would seem to be most complete is as follows:

Rubber Tired Vehicles—

Auto Trucks.

Large: Loaded; empty.

Small: Loaded; empty.

Passenger Automobiles

2-seated; 3 or more seated.

Carriages.

Motorcycles or Bicycles.

Iron Tired Vehicles—

1-Horse: Light; heavy.

2-Horse: Light; heavy.

Street Cars.

..

In Philadelphia, auto trucks are recorded as "light," "medium" or "heavy" without distinction as to size. In the Boro of Manhattan (New York) and in Newark all vehicles are recorded according to classification as "loaded," "half-full" or "empty," a separate weight for each being given. In Manhattan an additional classification, "motor buses," is found. In Manhattan and Newark "three-horse" and "four-horse" iron-tired vehicles are recorded separately, while in Brooklyn "trucks" and "wagons" are substituted for "one-horse," "two-horse" and "three-or-more-horse" iron-tired vehicles. A classification recommended by the Special Committee of the Am. Soc. C. E. on Bituminous Materials for Road Construction, varies considerably from that above. "One," "two," "three," "four," "five" and "six or more" horse-drawn vehicles are recorded. Motor-vehicle traffic is subdivided into "motorcycles," "motor runabouts," "motor touring cars" (4 or 5 seats), "motor touring cars" (7 seats), including limousines and landaulets, motor wagons or trucks. These classes are subdivided as "empty," "loaded," or "passenger vehicles." Neither of these variations would seem to be of more advantage than the above outlined classifications, except perhaps the additional classification of "motor buses" where these are in use.

The scales of vehicular weights as used in Brooklyn, Philadelphia, Chicago (taken from that originally in use by the Brooklyn Bureau of Highways) and in Manhattan (used also by Newark and St. Louis) are as follows:

Rubber-tired Vehicles.	Manhattan Newark St. Louis	Chicago	Brooklyn	Philadelphia	Tons
	Tons	Tons	Tons		
Large auto trucks, loaded..	8½	8	9		
Large auto trucks, empty...	4	4	4	Light auto truck	3.30
Small auto trucks, loaded...	2	3	3	Medium auto truck	6.00
Small auto trucks, empty...	¾	1½	1½	Heavy auto truck	8.50
Automobiles	1¾	1¾	1¾		
Carriages and wagons.....	½	1½	2		2.20
Iron-tired Vehicles.			Phlla.	Brooklyn	
3 horse trucks, loaded.....	9½	7½	5	Truck loaded	7½
3 horse trucks, empty.....	2¾	3½	5	Truck empty	3½
2 horse wagons, loaded.....	5¾	4	4	Wagon loaded	2½
2 horse wagons, empty.....	2	2	2	Wagon empty	1½
1 horse wagons, loaded.....	2½	2	2	Carriage	1
1 horse wagons, empty.....	1	1	1.20		

The variation in weights is greatest in loaded auto trucks, empty small auto trucks, rubber-tired carriages and loaded two and three-horse iron-tired vehicles. It is difficult to set up a standard scale of weights since conditions differ so greatly even within one city.

Since the scale of weights does not affect the proposed standard form for making counts, it would seem advisable for all cities making a census to determine their own scale by actual test of several hundred vehicles.

The duration of counts varies because of variety of purposes for which counts are taken. "Rush hour" counts are usually a necessity, even where a complete census has been taken, but there is little necessity for varying the form or method of counting unless the number and direction of vehicles only is desired. "Distribution counts," as these latter may be called, are always of special nature. In Newark and St. Louis the usual census counts are from 8 a. m. to 6 p. m. and 7 p. m. respectively. In Brooklyn and Chicago the counts are usually made from 8 a. m. to 5 p. m. and 6 p. m. respectively, the noon hour, 12, m. to 1 p. m., excepted. In Philadelphia the counts are made from 5 a. m. to 9 p. m. The above mentioned committee of the Am. Soc. of C. E. recommends 8, 12, 15 or 24-hour counts as may be necessary. In Buffalo counts are made from 5 a. m. to 7 p. m. One hour is usually the unit of time for all counts, though a 15-minute unit is used in Newark and New York.

Regular census counts are made once in 3 years in Newark, annually in Baltimore, Brooklyn, Buffalo and St. Louis, and every 3 months in Philadelphia. The committee of the Am. Soc. of C. E. recommends from 4 to 6 counts annually, with 3 days at each point. Counts are made intermittently in Chicago and Manhattan. A count of one day only is made in Baltimore, Chicago, Newark and St. Louis. Each point is counted for a period of three days in Buffalo. In Philadelphia each point is counted for four consecutive days—Friday to Monday inclusive.

Where traffic counts are made in congested districts to determine actual amount of congestion, it is obvious that certain vehicles offer greater obstruction to rapidity of flow than do others. In Brooklyn a "density factor" has been given to each vehicle which is of interest in that this indeed would seem to be of great service in studying

particularly acute congestion problems. The "density factor" was probably first used in London; the units there in use being given in the paper by Nelson P. Lewis, above referred to. The units used in Brooklyn are:

Rubber-tired Vehicles	Density Factor
Large auto truck, loaded.....	5
Large auto truck, empty.....	4
Small auto truck, loaded.....	3
Small auto truck, empty.....	2
Automobile	1
Carriage	2
Iron-tired Vehicles.	
Trucks, loaded	10
Trucks, empty	7
Wagons, loaded	7
Wagons, empty.....	4
Carriages	2
Street cars	10

Speed and flexibility are of prime importance, automobiles being capable of easiest movement, while heavy, slow-moving vehicles cause greatest delay.

Various forms for field notes and for office records are in use. But one form for field use and one or, at most, two forms for office use are needed. Accompanying this report are two forms suited for standard use. They correspond in general with most of those now in use and their adoption will make possible the most thoro and economical means of making traffic counts.

Respectfully submitted,

J. C. HALLOCK, Chairman,
A. PRESCOTT FOLWELL,
HARLAND BARTHOLOMEW,
Committee on Traffic and Transportation.

NECESSITY FOR LIMITING THE LOADS, SPEED AND SIZE OF VEHICLES.

By Eugene W. Stern, Chief Engineer in Charge of Highways, Boro of Manhattan, City of New York.

During the past year a great deal of damage has been caused to some of the best pavements in the Boro of Manhattan, City of New York, by heavily loaded steel-tired trailers hauled by motor vehicles. The destruction has been so rapid that it has brought to the attention of the authorities the necessity for limiting the loads on vehicles to be hauled over the city streets.

In recent years there has also developed a greatly increased use of the motor vehicle, with increase in size, so that many of the streets in business sections of the city are becoming congested. Unless some limitation is placed upon the size of vehicles, this condition will continue to become worse.

As the weight and size of the vehicle increases, the question of limiting the speed also must be considered, for it becomes evident that what would be a reasonable speed for an ordinary size vehicle of moderate weight would be detrimental to the public interests in larger and heavier ones.

DAMAGE CAUSED BY VEHICLES TO CITY STREETS.

The most damage seems to be caused by steel-tired vehicles hauled by motor trucks, or trailers, as they are called.

The case in point is here given: A contractor's outfit hauling rock from the subway excavation on Broadway is made up of a tractor and trailer. The latter carries six large buckets, weighing about 15 tons. Its wheels are 41 inches in diameter with 8½-inch wide steel tires. The load per inch width of tire is about 1,400 pounds.

The springs on the front axle are spiral and on the rear, flat. They are very stiff, and this fact has unquestionably contributed towards the destructive effect of the wheel loads of the trailer. The

jarring effect of the loaded vehicle is such that people along the route traveled complain about excessive vibration in their buildings.

The route traversed has been along West Forty-second street, from Eighth to Tenth avenues; north on Tenth avenue to Fiftieth street; west on Fiftieth street to the dump dock on the North River.

The age and character of pavements on the route is as follows:

Forty-second street, from Eighth to Ninth avenues—Sheet asphalt on concrete foundation, completed July 22, 1912.

Forty-second street, from Ninth to Tenth avenues—Improved granite on concrete foundation, completed November 14, 1912.

Tenth avenue, from Forty-second to Fiftieth streets—Improved granite on concrete foundation, completed February 26, 1913.

Fiftieth street, from Tenth to Eleventh avenues—Sheet asphalt on concrete foundation, completed August 27, 1912.

Fiftieth street, from Eleventh to Twelfth avenues—Improved granite on concrete foundation, completed May 25, 1912.

It will thus be noted that these pavements are all substantially about four years old. They are considered among our best pavements, and have been laid in conformity with the latest specifications. Up to the time when the damage began to be done by the above mentioned trailers, no appreciable amount of wear had been noticed beyond what ordinarily might be expected on thoroughfares with as much traffic as have the streets above mentioned.

The mischief has all been done in a very short space of time (about nine months), and has amounted to 5,400 yards of repairs on granite (equal to 32 per cent. of the total area), costing \$6,000, and 1,900 yards of repairs on sheet asphalt (equal to 30 per cent. of the total area), costing \$1,900; whereas, prior to this time, the average cost per year of maintenance on the granite was \$150, and on the sheet asphalt \$70.

The accompanying photographs show the kind of damage that has been done. On granite pavements the granite blocks have been literally crushed and ground into powder. In many cases the blocks were split. The granite used has given splendid service on other streets of the city. The granite on Forty-second street, between



Truck and trailer with two rear wheels on steel tires, and about 5 tons on each. It cut up granite and asphalt pavements as shown in accompanying photographs.



Beginning of Destruction of Granite Pavement.

Ninth and Tenth avenues, was quarried at North Jay, Me., and has a crushing strength of about 20,000 pounds per square inch. The granite used on Tenth avenue, from Forty-second to Fiftieth street, was quarried at Rockport, Mass., and has a crushing strength of 25,000 pounds per square inch. The granite used on Fiftieth street was quarried at Salisbury, N. C., and has a crushing strength of 40,000 pounds per square inch.

On the sheet asphalt, the destructive effect has been equally startling. In some places it has been ground to small bits, in other places the wearing surface has been completely broken and cracked. It shows many depressions, waves, ruts and shoves.

In many cases the 6-inch concrete base has been shattered; however, in many other cases where the wearing surface has been damaged, the foundation remains intact.

The speed of these vehicles was about 6 miles per hour in the day time, and at night it was considerably higher—12 and 14 miles per hour, and even 16 at times.

The question of restraining the contractor from hauling such excessive loads was submitted to the corporation counsel, and his answer was that as there was no ordinance restricting the loads on vehicles, it would be very difficult to obtain any relief until suitable legislation was obtained.

The effect of rubber-tired traffic has been carefully investigated, and practically no damage has been caused by motor vehicles in which all of the wheels are covered with rubber, beyond what is reasonable. Altho there are some types of heavily-loaded trucks in use in the city, our first-class pavements show practically no additional expense for maintenance beyond a reasonable amount.

The manufacturers of motor vehicles have found by experience that about 750 pounds per inch width of tire is about all the load the rubber tire will stand, and this load, together with the resiliency of the rubber and the adequate springs on motor vehicles which good construction demands, seem both together to be the saving features in protecting the pavements against undue wear, even under heavy loads.

The trailer, however, comes in an entirely different class. Not



Further Progress in Destruction of Granite Block Pavement.



Measurement of Amount of Destruction.

being rigidly connected with the vehicle having the engine and the more or less delicate mechanism, it need not have the rubber tires nor the easy springs to prevent damage to the tractor, hence builders of these, who form a distinct class from the motor-vehicle manufacturers, have allowed their fancy no restrictions in the designs of the tractors, their principal object being to provide a vehicle having the greatest tonnage capacity at the least cost, without considering the destructive effect on the pavement caused by the excessive loads, narrow steel tires, small diameter of wheels, and inadequate springs.

It becomes evident, therefore, that immediate action must be taken to protect not only the pavements of the cities and the municipalities immediately surrounding the cities, but also the country highways which are liable to be exposed to such kinds of traffic, or the taxpayers will be called upon to make very heavy payments to maintain their streets and highways, altho these may have been constructed in a thoroly first-class manner and in accordance with the latest ideas.

It goes without saying that a vehicle that would break down the best kinds of city pavements in a short space of a few months, will cause much greater damage to even a first-class country highway much more rapidly.

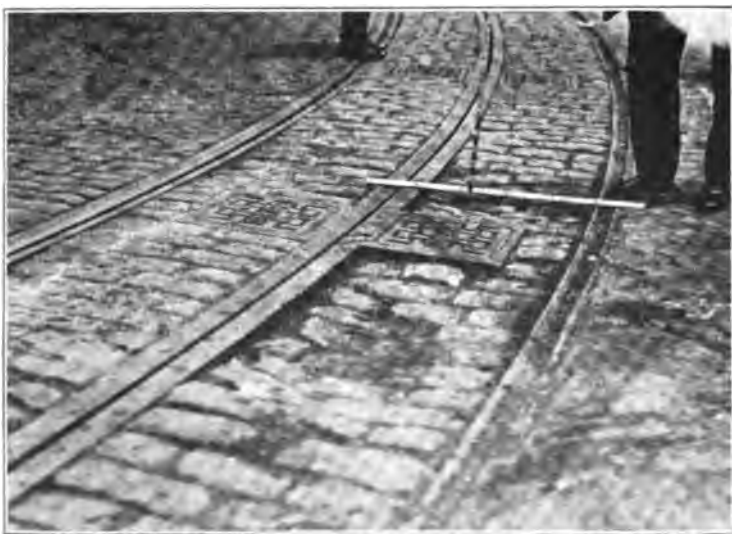
It would appear to the speaker that regulations properly framed to protect the pavements against the destructive effects of excessive loading in vehicles, should take into account the following factors:

1. That the wearing or damaging effect of wheel loads on pavements is a function of (a) the load; (b) the diameter of the wheel; (c) the width of tire; (d) whether or not the tire is of a resilient material, such as rubber, or of steel; (e) the kind of springs.
2. That speed has considerable to do with the damaging effect of heavy loads.

An investigation of the laws and ordinances governing the weights and loads of vehicles, etc., adopted by 8 states and 49 cities in the United States and Europe, goes to show that only a few laws have been drafted in accordance with modern conditions. It is surprising that even today in this country, certain communities require that the width of the tire should depend on the diameter of the axle, regardless of the loading; others make no distinction in the



Note all Stages of Deterioration Visible on Surface.



Where the Line of Travel of the Trucks Crossed the Street Railway.

regulations between a wheel large or small in diameter, while still others treat rubber and steel-tired wheels the same.

Among the most up-to-date ordinances are the following:

Chicago, Ill.—

Maximum weight of vehicle, 15 tons.

Maximum load on any one axle, 12 tons.

Maximum load on the wheel, 6 tons.

Maximum load per inch width of tire, 1,000 pounds.

Maximum length, 40 feet.

Maximum width, 8 feet 6 inches.

Speed: Compatible with safety, but not to exceed 9 miles per hour. Not to exceed 4 miles per hour when truck has defective tire which would cause injury to pavement.

Motor trucks must have rubber tires.

Trailers may have steel tires.

New York State—

Maximum weight of vehicle, 14 tons.

Maximum load on any one axle, 9 tons.

Maximum load per inch width, 800 pounds.

Maximum width, 8 feet 4 inches, except traction engines which may have a width of 9 feet 2 inches.

Speed: Over 4 tons, 15 miles per hour; over 6 tons, 6 miles per hour with steel tires; 12 miles per hour with rubber tires.

State of New Jersey—

Maximum weight of vehicle, 12½ tons.

Maximum load per inch width of tire, 800 pounds.

Speed: 4 tons, 12 miles per hour, iron tires; 6 tons, 8 miles per hour, iron tires, 10 miles per hour, rubber tires.

State of Pennsylvania—

Maximum weight of vehicle, 12 tons.

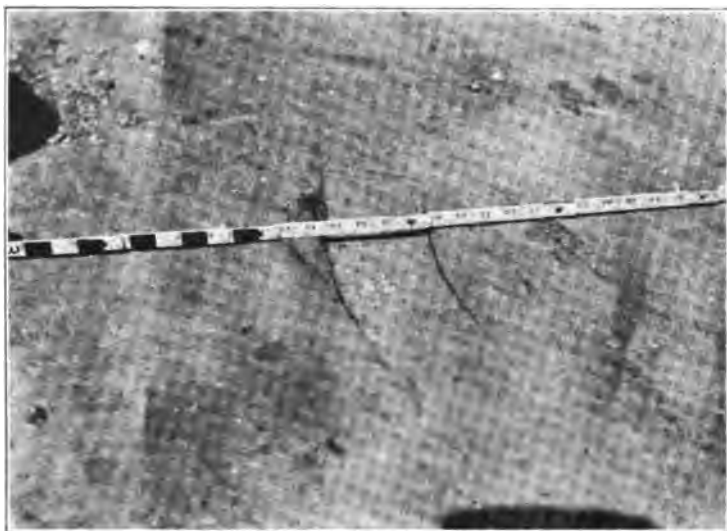
Maximum load on any one axle, 9 tons.

Maximum load per inch width of tire, 750 pounds.

Maximum width, 7 feet 6 inches; for buses in large cities, 8 feet 4 inches.

State of Massachusetts—

Maximum weight of vehicle, 14 tons.



One Cut of the Trailer Wheel in an Asphalt Pavement. The Edge of a Large Hole Caused by this Excessive Traffic on the Left.



Measurement of Depth of Holes Worn by the Excessive Traffic.

Maximum load per inch width of tire, 800 pounds, except for hard pavements.

Speed: 4 tons, 15 miles per hour; 6 tons, 6 miles per hour, iron or steel tires, 12 miles per hour, rubber or similar tires.

Oakland, Cal.—

Maximum weight of vehicle, 14 tons.

Maximum load per inch width of tire, 800 pounds, except for hard pavements.

Speed: 4 tons, 6 miles per hour, iron or steel tires, 12 miles per hour, rubber tires.

England—

The English have much the most complete and scientific ordinance of any that the speaker has examined.

Maximum weight of vehicle, 12 tons.

Maximum load on any one axle, 8 tons, for trailers 4 tons.

Maximum weight of vehicle without load, 5 tons.

Combined weight of motor car and trailer, $6\frac{1}{2}$ tons.

Weight on axle to be proportioned to diameter of wheel.

The load per inch width of tire, steel, shall be 840 pounds, for wheels 3 feet in diameter; and an additional allowance of 9 1-3 pounds for every additional inch increase in diameter beyond 3 feet, and for wheels less than 3 feet in diameter, a deduction of 18 2-3 pounds per inch width of tire for every inch less in diameter than 3 feet.

Vehicles for military service limited as follows:

Weight of car unladen, 6 tons.

Weight of car with trailer, 8 tons.

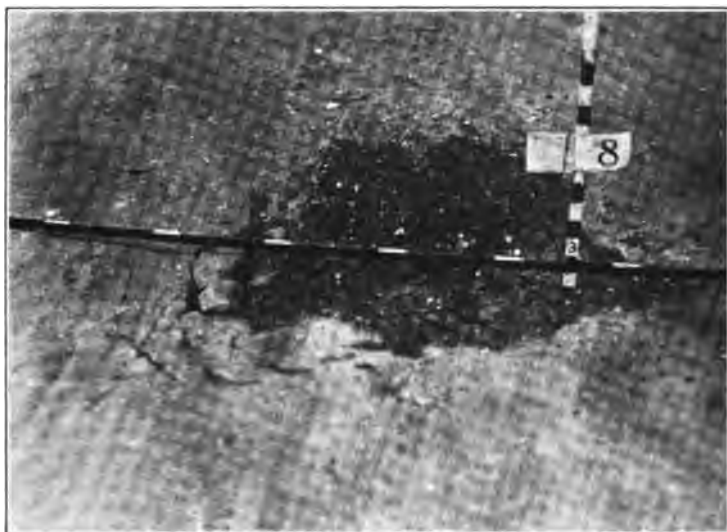
Unit of registered axle weight with tires shod with cross bars, 560 pounds.

Maximum width, 90 inches for 3 tons; 90 inches for trailer.

Speed: Dependent on axle weight for iron-tired vehicles—6 tons, 12 miles per hour, for rubber tires; over 6 tons, 8 miles per hour, for rubber tires. Should car unladen weigh more than 3 tons, speed is limited to 8 miles per hour. If motor draws trailer, maximum speed is 5 miles per hour.

WIDTH OF VEHICLES.

Unless some limitation is placed upon the size of vehicles, the tendency will be to make them larger and larger, until they will become a nuisance and congest the highways. This is now becoming evident in the city of New York, as well as in other cities.



Asphalt Surface Worn Thru and Disintegrating on Edges of Hole.



Almost Complete Destruction of the Asphalt Area in Sight.

In order to provide reasonable standing room on each side of a street and, at the same time, allow traffic to proceed in both directions, we are forced to limit the width which vehicles take up.

Many of our streets have roadways only 30 feet between curbs. It thus becomes evident that vehicles over 7 feet in width do not allow for two to pass, even using the utmost care. While it is becoming necessary to widen roadways in this Boro, it is very difficult to add more than 2 feet to each side, a 30-foot roadway is thus converted into a 34-foot roadway. In this case, a 7½-foot width for a vehicle would be the limit.

In conclusion, the speaker submits that this subject is one of paramount interest to all cities, and that the time has now arrived when the issues must be squarely faced.

It is hoped, therefore, that a thoro discussion of this matter will ensue; and that the result will be a crystallizing of ideas on this most important subject.

APPENDIX.

Memoranda Regarding Dimensions, Weight, etc., of Trucks used on the Subway Construction Work to haul Rock from Shafts at Thirty-ninth, Forty-first and Forty-third Streets, New York, N. Y.

Trailers: Platform over all 22.2 feet by 8.6 feet.

Wheel Base: 11.5 feet.

Tread Base: 6.55 feet.

Length over all, including tractor and trailer: 33 feet.

Rear wheels of trailer: 41 inches diameter, 8½ inches wide, steel tires.

Rear wheels on tractor: 32 inches diameter, with double 6-inch rubber tires.

Axle of trailer: 2¾ inches by 5½ inches deep.

Rear springs, flat: 53 inches long, having 20 leaves ½-inch thick by 3½ inches wide.

The trucks carry six skips, which, when loaded with stone, weigh from 2½ to 3 tons each.

There are ten of these trucks in operation. They work 16 hours per day and each makes about one round trip every hour. The total number of trips, therefore, for the ten vehicles is 160 per day.

MEMORANDA REGARDING GRANITE.

Location—Forty-second street, Ninth to Tenth avenue. Quarry—North Jay, Me. Crushing strength—20,000 pounds per square inch.

Percentage of repairs—1915, .4; 9 months of 1916, 45.

Location—Tenth avenue, Forty-second to Fiftieth street. Quarry—Rockport, Mass. Crushing strength—25,000 pounds per square inch.

Percentage of repairs—1915, .5; 9 months of 1916, 26.

Location—Fiftieth street, Eleventh to Twelfth avenue. Quarry—Salisbury, N. C. Crushing strength—40,000 pounds per square inch.

Percentage of repairs—1915, .6; 9 months of 1916, 36.

DISCUSSION

MR. POLLOCK: Mr. Stern's paper is one of so great importance that it seems too bad to let it go without a few words of commendation. It seems to me that he is working along the right line. Some months ago, as far away as San Antonio, they were taking this matter up, and Mr. Helland, the city engineer, who is attending this convention, wrote to me asking what had been done in New York city in the line of legislation, ordinance to regulate excessive loads on pavements. Last winter, I think it was, some of the engineers of New York city drew up quite a detailed form of ordinance for taking care of this, but heavy charges were imposed on vehicles, and the law department claimed this was unconstitutional as it was double taxation. This is the most detailed attempt at legislation that I have seen. That is a matter that will have to be taken into consideration in any attempt at legislation on this subject. It seems to me that it is a matter of enough importance for this society, thru a new committee or thru one of its present committees, such as the

traffic committee, to draft some reasonable rules which municipalities can use in trying to regulate this method of transporting heavy goods. I have had a chance to personally observe these heavy motor trucks and trailers which Mr. Stern referred to, on Forty-second street. Of course this is an exceptional case, but we cannot tell, it may become the rule if nothing is done to regulate the loading on steel tires. A great many states have passed laws regulating the loads to be carried on tires. Some of them, as Mr. Stern brought out, are based on the size of the axles. Whatever is done in that line should take into account the speed. I think in this case on Forty-second street the speed had a great deal to do with the trouble.

THOMAS J. WASSER, County Engineer of Hudson County, New Jersey: In discussing this paper by Mr. Stern, I would like to say that the state of New Jersey has realized the conditions for years and amended the automobile law so that the commissioner is empowered to pass upon the construction of motor vehicles. Last May the commissioner appointed a committee of county engineers of the state to investigate and report to him conclusions which would govern the regulation of commercial motor vehicles. This committee has had several meetings and they have now prepared in preliminary form their findings, which agree in every detail with what Mr. Stern recommended. One of the points that Mr. Stern especially brought out was speed. He spoke of an exceptional vehicle that while it was under the eyes of the police, traveled about 6 miles an hour, and at times, when unobserved, traveled at 15 miles per hour. We realized that, and covered that point in our preliminary paper. We had an open hearing last week in Newark, at which were present representatives of motor truck manufacturers, tire manufacturers and users of motor vehicles. In this paper, which was prepared, there were two clauses which came in for criticism. One of them, we admitted, it was impossible to comply with, that is, to carry an extra wheel to replace a damaged wheel. As a substitute I asked the users of motor vehicles what they would suggest. They said that it was impossible to carry an extra wheel on account of its tremendous weight and the impossibility of substituting it on the road without the necessary machinery. They said that the law should provide an extreme penalty for running with a damaged wheel over a road. It is impossible to fix the figure as

to what the damage should be, except to make it severe. I have in mind a bituminous road in this state leading to New Brunswick, built last year, and my observation this summer showed that a motor vehicle heavily loaded had passed over it with a damaged tire, which left two cuts 12 inches apart, $\frac{1}{2}$ inch wide and $\frac{3}{4}$ inch deep. The truck damaged probably 2 miles of that road. Water will get in and disintegration may take place, and it is impossible to say in dollars and cents what the damage would be.

The other clause was requiring trucks to carry way-bills in order to ascertain weight of load.

We consented to give the manufacturers of trucks and tires an open hearing some time in November, at which time they could present their side. We have regulated the speed, the size of the tires, and size of wheel load.

In regard to the law that has been in effect in some of the states for a number of years allowing 800 pounds to every inch of tire, we found that it was adopted from European countries. In examining a number of tires I saw probably 16 or 17 tires represented as 5-inch tires that varied as much as $\frac{3}{4}$ inch, so if we used 800 pounds per inch width of tire it would be necessary to change the width of the tires. That would necessitate changing of dies by some of the tire manufacturers, so we decided it should be a wheel load in place of pounds per square inch of tire, and the load so proportioned that the rear axle carries $\frac{2}{3}$ of the entire load, one rear wheel to carry one-third of the entire load. The manufacturers agree to put a plate on the side of the truck giving the light weight and the carrying capacity; then one-third of that shall be the basis for the diameter of the wheel and size of tire, as per schedule for rear-wheel loads.

MR. REIMER: I am a member of this committee in New Jersey. It is working out the idea of the tremendous carrying capacity of motor vehicles which in New Jersey exceeds almost, if not quite I was going to say, the carrying capacity of the railroads. We realized the necessity for some action, but up to the present time we all have been talking only in generalities, and have not gotten down to recommendations. We feel in New Jersey that we have made the first specific recommendations, and we hope to have them put into legislation this coming winter. The work

which this committee has done is going to be further discussed in open meetings, and it is going to receive the criticism of all the manufacturers of trucks and tires, automobile clubs, and also the users of horse-drawn vehicles. The damage to roads by rubber tires does not approach the damage to roads by steel tires, load for load. But the great damage done by motor trucks is due to overloading narrow tires, which become broken, and then you get a sledge-hammer blow with every revolution of your wheel. It is absolutely necessary, therefore, that, the moment a truck wheel is damaged, the law to be so mandatory and stringent and so highly penalizing that it will not be to the interest of the truck owner to insist that his driver make the trip irrespective of damage to the road. We are therefore going to recommend that the penalty for proceeding on any road where the wheel has become broken shall be about \$1,000. At the present time we know it to be the case that truck owners have a regular railroad schedule, we will say between New York and Philadelphia, or New York and Trenton, and they compel their men to go and return on time. The orders are to get there and get back, and the driver of an automobile truck, simply because he has a big chunk of rubber out of his driving wheel, isn't going to stop for repairs or send to the nearest service station for another wheel at the expense of possibly reporting late and losing his job. Therefore we insist, as we say in these recommendations, on a sealed governor, so that when a man has made a trip and he lays up along the road, at refreshment stops, etc., he does not exceed the speed limit and he doesn't tear our roads to pieces.

I have distributed on the chairs this tentative report, which I hope you will all take with you, and we would be pleased to have any comments by the engineers of this Society sent in to us at any time after you have had an opportunity to go over the report, either of criticism or favorable comment. I have also here a letter written by Col. Sohier, of Massachusetts, which, without reading, I would ask be made a part of our records, and also that this report of New Jersey be made a part of the records.

Report of Special Committee, Motor Vehicles

The Special Committee appointed by William L. Dill, Commissioner of Motor Vehicles of the State of New Jersey, on May 4,

1916, for the purpose of preparing rules and regulations to govern the use of motor vehicles or trucks on the highways of the State of New Jersey, submit the following:

1. No commercial vehicle or truck of over 4,000 pounds weight shall be more than 96 inches in width outside measurements, except that in extreme cases the Commissioner of Motor Vehicles shall be privileged to issue permits for the operation of motor vehicles or trucks with a width of load over 96 inches where the weight of the load is not a factor.

2. That no commercial vehicle or truck shall be equipped with metal tires that may be in contact with the surface of the road, nor shall any such vehicle or truck be equipped with any tires which have a partial contact of the metal with the surface of the road.

3. That no commercial vehicle or truck shall be equipped with any tire covering of metal, or with any lugs or hobs, or other sharp devices which would be in contact with the surface of the road, except chains which may be used in accordance with the motor vehicle act.

4. That the height of all commercial vehicles or trucks be limited to 12 feet 2 inches.

5. That all commercial vehicles or trucks should be equipped with sealed governor, the speed to be regulated as per schedule attached hereto.

6. That no commercial vehicle or truck shall be equipped with center searchlight, but that the lights of all commercial vehicles or trucks shall be in conformity with Section 4 of the Motor Vehicle Act.

7. That the extreme length of motor vehicles or trucks shall not exceed 23 feet 6 inches.

8. That not more than one trailer shall be allowed to any commercial vehicle or truck; that in every case said trailer shall be equipped with rubber tires.

9. That all commercial vehicles or trucks shall carry a spare wheel, so as to avoid the possibility of any part of the steel rims coming into contact with the surface of the road, should the rubber tires become broken or otherwise damaged.

10. That all drivers of commercial vehicles or trucks shall carry way bills for each load, said way bills to show the gross weight and net weight carried.

11. That the commercial size of tires used on all commercial vehicles or trucks shall be determined on the maximum width of rubber.

12. That all license fees shall be based on the maximum wheel load carried on same, said wheel load to be determined by the size of tire used and adopted in conformity with the schedule hereto attached.

13. That all trailers or semi-trailers shall be licensed on their carrying capacity.

14. That all counties in the state shall place signs showing the clearance on all bridges in their respective counties, if the clear headroom is less than 12 feet 6 inches.

15. That a special permit be secured from the State Motor Vehicle Commissioner for the use of trucks as pleasure vehicles.

16. That trucks or commercial vehicles equipped with undersized tires shall not be licensed.

17. **FOR REAR WHEELS**—That one-third of the gross weight of truck and carrying capacity combined must be within the limits of the schedule of the respective diameter of wheel, size of tire and speed in miles per hour as shown in schedule hereto attached.

18. That the front axle shall carry the balance of the gross weight of truck and load combined and must be within the limits of the schedule of the respective diameter of wheel, size of tire and speed in miles per hour for single tires, as shown by schedule hereto attached.

19. That all commercial vehicles or trucks carrying any load extending beyond the sides or ends of the outside dimensions of said vehicles or trucks, shall have displayed at the outside extremity of load a red flag which shall be not less than 12 inches square and shall be so hung as to present a full view to approaching vehicles.

Schedule Showing the Maximum Width and Height of Motor Vehicles Allowed on the Ferries Coming into the State of New Jersey.

STATEN ISLAND TRANSIT RAILWAY COMPANY.

Ferryboat Tottenville, Clearance 12 feet 4 inches overhead.

Perth Amboy, Clearance 12 feet 6 inches overhead.

Tottenville, Clearance 7 feet 5 inches width.

Perth Amboy, Clearance 7 feet 7 inches width.

PUBLIC SERVICE RAILWAY COMPANY.

BERGEN POINT.

Boat.	Height.	Width.	Width between wheel guards.
Bayonne	11.7	10	7.9
Public Service	11.5	8.2	6.6
Public Service	11.5	9.9	9.1

EDGEWATER.

Englewood	10.9	9.1	7.1
Leonia	12.8	9.3	7.3
Edgewater	11.9	9.6	8.0
Fort Lee	12.2	9.9	7.7

CARTERET FERRY COMPANY.

Overhead clearance of boats	13 feet
Clearance of passageway	9 feet 6 inches
Passageway between combings	7 feet 6 inches

	Height.	Width.
Penna. R. R.	12 feet 4 inches	10 feet
D., L. & W. R. R.	12 feet 2 inches	9 feet 6 inches
Erie R. R.	12 feet 6 inches	10 feet 6 inches
Central R. R.	12 feet 6 inches	10 feet
West Shore R. R.	12 feet	8 feet
Penna. R. R. at Camden		8 feet 6 inches
Penna. & Reading R. R.		8 feet 6 inches

DYCKMAN STREET FERRY.

Figures not secured.

PROPOSED STANDARD RELATIONS OF SIZE OF TIRE, DIAMETER OF
WHEEL, LOAD ON REAR WHEEL, AND SPEED OF TRUCK.

Size		32	34	36	38	40	42	Speed Miles per Hour
2 in.	Single	565	595	625	660	690	720	20
2½ in.	Single	840	890	940	990	1040	1090	20
3 in.	Single	1125	1190	1250	1315	1375	1440	20
3½ in.	Single	1415	1490	1565	1640	1715	1790	18
4 in.	Single	1690	1780	1875	1970	2065	2155	16
5 in.	Single	2250	2375	2500	2625	2750	2875	14
6 in.	Single	2815	2970	3125	3285	3440	3595	12
7 in.	Single	3375	3565	3750	3940	4125	4315	10
2 in.	Double	1125	1188	1250	1312	1375	1438	18
2½ in.	Double	1675	1775	1875	1975	2075	2175	18
3 in.	Double	2250	2375	2500	2625	2750	2875	16
3½ in.	Double	2825	2975	3125	3275	3425	3575	14
4 in.	Double	3375	3560	3750	3940	4125	4310	12
5 in.	Double	4500	4750	5000	5250	5500	5750	12
6 in.	Double	5625	5940	6250	6565	6875	7190	10
7 in.	Double	6750	7125	7500	7875	8250	8625	10

*Schedule Showing Annual Fee and Fee in September, Based on
Gross Weight.*

Gross weight of truck and carrying capacity. Pounds.	Annual Fee.	Fee in September.
4,000 or less	15.00	7.50
4,000 TO 5,000	17.50	8.75
5,000 6,000	20.00	10.00
6,000 7,000	22.50	11.25
7,000 8,000	25.00	12.50
8,000 9,000	27.50	13.75
9,000 10,000	30.00	15.00
10,000 11,000	32.50	16.25
11,000 12,000	35.00	17.50
12,000 13,000	40.00	20.00
13,000 14,000	45.00	22.50
14,000 15,000	50.00	25.00
15,000 16,000	55.00	27.50
16,000 17,000	60.00	30.00
17,000 18,000	65.00	32.50
18,000 19,000	70.00	35.00
19,000 20,000	75.00	37.50
20,000 21,000	81.25	40.63
21,000 22,000	87.50	43.75

22,000	23,000	93.75	46.88
23,000	24,000	100.00	50.00
24,000	25,000	106.25	53.13
25,000	26,000	112.50	56.25
26,000	27,000	118.75	59.38
	27,000	125.00	62.50

By the Committee,

JOHN J. ALBERTSON,
GARWOOD FERGUSON,
ALVIN FOX,
THOS. J. WASSER, *Chairman*,
FREDERIC A. REIMER, *Secretary*.

Approved:

WM. L. DILL,
Commissioner of Motor Vehicles.

W. D. SOHIER, Chairman of Massachusetts Highway Commission (by letter to George C. Warren): I have read the regulations and certainly should comment on them very favorably.

I have felt for some time that we ought to have a regulation in this state regulating and limiting the extreme width of vehicle and load, and also the height. I have also felt that we should have further regulations on speed, and that the trucks, now that they are running on our country roads in such large numbers on main thru lines between cities that are forty and fifty miles apart, are doing a tremendous amount of damage to the roads and are requiring much more expensive types of road construction, and would require still more expensive types in the future. Consequently, I consider that they are not paying anything like a reasonable fee.

In fact, I believe there should be an absolute limit on the extreme weight, much lower than the one we now have in Massachusetts, provided trucks are to be used over what might be called country roads or outside of paved streets. Many of our country roads are very seriously damaged and almost destroyed by trucks using them, especially in the spring when the frost is coming out of the ground, or after a long spell of wet weather when the gravel roads are soft. The trucks even get stuck and can't get thru, but meantime they make what was a good country road and would remain

such for many years with the ordinary traffic that went over it, look like a plowed field.

We have in this state, as you undoubtedly know, substantially the same law that exists in England and France, to wit, we have a limited weight, nothing to be moved over the roads without a permit which has more than 800 pounds per inch width of tire resting on the road surface, and this has the limitation "unless such highway or bridge is paved with brick, block, sheet asphalt or concrete pavement or surface." We also have a law that prohibits the use of any device which substantially cuts into or injures the road surface, and makes the owner of the vehicle or operator of the vehicle responsible for damages if he violates the law.

We also have a law limiting weight, which says that nothing can be moved on the roads weighing over 14 tons, including vehicle and load.

We have the right in this state to limit the weights which can be moved over the bridges to 6 tons, including vehicle and load.

We have a speed limit not exceeding 15 miles an hour when the load is in excess of 4 tons. If it exceeds 6 tons, including the vehicle, it can only be moved at 6 miles an hour if it is equipped with iron or steel tires, or not more than 12 miles an hour if equipped with hard rubber or other similar substance.

As I stated above, our law is, in my opinion, not sufficient to safeguard the country roads, and I am inclined to think on the city streets and everywhere, the limits should be placed at somewhere around 12 tons, including vehicle and load.

I haven't gone into the graded speed particularly in the New Jersey recommendations, but it would seem to me fair to have some such regulation. In talking with many highway commissioners from various states, as I have been doing for the past two years, I find that practically every one of them in the thickly-settled states is having the same sort of trouble with trucks damaging the roads, and they all believe that we need restricting regulations both as to speed, weight, and width of tire. I think most of them agree with me that the use of heavy trucks should be restricted to particular routes where the roads were sufficiently strong to hold them up and the bridges would be safe.

Under our old law the country towns had the right to post a bridge "not exceeding 3 tons, including vehicle and load." This, like the 6-ton permit which is the limit everywhere, didn't make the owner of the vehicle responsible for damage if he moved a greater weight over the bridge and thereby injured it, but it prohibited his right to recover any damages from the city or town. We have had many illustrations.

One truck undertook to go up thru a country road into New Hampshire, and it broke thru the bridge which was the dividing line between one of our little towns and a small town in New Hampshire, and the truck went down into the stream. Both towns attached the truck, but meantime the stream rose and the truck was substantially destroyed by the flood. I don't think, under our present law, that the towns have any right to recover against the truck for breaking the bridge, but I believe in the New Jersey regulations it would be wise to provide that if any road or bridge is injured by any vehicle going over it with a load in excess of the amount allowed by law with tires, or without the width of tire required by law, or at a greater speed than is allowed, that the owner of the truck and the operator thereof should both be responsible to the city, town, county, or state, whoever had charge of the maintenance and upkeep of the bridge or road. It should be required to pay all damages occasioned by the use of the vehicle and the violation of the law.

We had one lumber truck in the little town of Richmond that in one day broke five little culverts, and it cost the town \$3 on the tax rate to replace those culverts. Richmond is a poor town with a valuation of under a million dollars.

We had another truck that went over the bridge between Ayer and Shirley and broke it so the bridge had to be rebuilt. It cost them about \$7,000. Meantime all the traffic and all the farmers had to go a mile and a half out of their way to get from one town to the other.

I could give you many other illustrations. I remember that when the Roslindale bridge gave way years ago, they thought of indicting the president and all the directors of the Boston-Providence Railroad, and the same thing was true when the Chester bridge gave way under the Boston & Albany. Certainly we should say that any

railroad corporation was grossly negligent if it put on 120-ton locomotives and moved them over bridges that had been built to carry only 50 tons. Yet on our highways that were built merely for horse-drawn vehicles with loads not exceeding at any rate 3 tons and used by only a small number of vehicles a day, anyone who has the money and desires to do so may take a 6-ton truck with a 7-ton load over that road and practically destroy it, very likely breaking all of the culverts, and doing a damage entirely out of proportion to the benefit secured by the truck owner.

We certainly need regulations on the line of the ones suggested for New Jersey, and I believe we should also find some way to keep such extremely heavy loads off of our country roads, at any rate until such time as the community has been able to secure the money to build roads and bridges that will not be destroyed when they are used by such vehicles.

A MEMBER: May I ask the last speaker what influence the action of chains would have on the roads and what action is taken, if any, to limit the size or character of these chains? I have in mind a 5-ton double-tire truck, overloaded possibly 50 per cent., and going along the street with probably four or five 1-inch chains strapped around the tire to prevent slipping on a partially frozen surface. That seems to cause some trouble to the streets. Whether it is possible to limit the size of the chains and the number of them put around tires is what I would like to find out.

MR. REIMER: In New Jersey we have nothing controlling the size or the number of chains to be used on rear wheels. It is a question which I think is worthy of consideration.

MR. HANSELL: One of the most serious conditions we have in our section is the effect of these machines. They are being used more and more every day, and the weight increased. In our territory we haven't the money to put on permanent pavements as in the large cities. We have country roads that have been covered with bituminous surfaces, and a law which is applicable to a city like Newark wouldn't do us any good, and we couldn't enforce an automobile law that would prevent a man from hauling with a 5-ton truck unless we had some regulation by which the police could force him onto some other road.

MR. NORTON (by letter) :

The condition as noted by the author is one which is becoming of vital importance to the larger cities.

From the fact that many heavier loads on steel tires have been used without these serious results, both in New York and many other cities, the conclusion must be that the load or steel tire alone are not primarily the cause of the condition. The two other factors are diameter of wheel and speed.

In Buffalo some damage to pavement has resulted from steam shovels and similar machines passing thru streets, altho the total wheel load and load per inch width of tire were not excessive. As the speed was low, the most plausible reason seems to be in the small diameter of the wheels. However, the most noticeable factor is evidenced by the vibration caused by the more rapid movement of the motor vehicle. At even considerable distances the vibration of ground and buildings caused by motor trucks is most noticeable, while heavy surface cars and horse-drawn vehicles cause but a fraction of such. This vibration can be produced only by an action similar to a series of blows. The rapidly moving wheel is unable to follow the inequalities of the pavement surface, but leaves any small elevation or projection and travels a slight distance before gravity brings it to the surface of the pavement again. With rubber-tired vehicles this is not so destructive of the surface, but it may be well to consider what possible effect such repeated heavy blows may have upon the concrete foundation. Without the rubber tire, the effects of this pounding has been most strikingly shown.

From the above considerations, the writer must assert that the large factor in this destructive action is due to increased speeds and that such must be strictly regulated if we are to maintain pavements for such vehicles.

REPORT OF COMMITTEE ON REFUSE DISPOSAL AND STREET CLEANING.

E. R. Conant, Chairman, Chief Engineer, Savannah, Georgia.

Your committee is presenting to you several papers, which bear directly upon the recent progress made in the modern advancement of two very important branches of municipal work, viz.; refuse disposal and street cleaning.

Considering refuse disposal. After making numerous inquiries we learn that no large refuse disposal plants have been constructed during the past year, altho some half dozen plants of small units have been installed, and several are under construction.

Between 1908 and 1914 over a score of incinerators, a number of reduction plants, and a large number of crematories were installed in the United States. The improvement in modern methods of disposal of city waste is going along steadily and continuously, but during the past year the progress of actual construction has perhaps not kept pace with the previous years. This may be due to several reasons: First, the financial condition of many of the cities during the past year. Second, fear on the part of city officials to adopt modern types of destructor plants, on account of much publicity having been given to alleged failures of successful operation of several that have been constructed. Third, the realization that a thoro study should be made of local conditions before directly entering upon the question of actual construction.

While perhaps the number of installations during the past year has not equaled that of previous years, we do not consider that there has been a backward step along this line of work. A more thoro research of the work was carried on than ever previously, for municipalities and engineers have come to realize that local conditions are so varied that the problem of disposal of refuse by modern methods must be to a certain extent solved by each municipality. No standard type of construction of furnace can be adopted without variations to meet local conditions, and no doubt mistakes have been made by some municipalities adopting destructor or reduction

plants in not making the necessary investigations to ascertain which would be the most applicable and adaptable to meet existing local conditions. Again dissatisfaction, in our opinion, in some instances has been brought about by some contractors of plants making guarantees that only technically can be lived up to under special conditions, which conditions after the plant was put in operation proved to be somewhat different from what the preliminary study indicated. Guarantees for destructor plants are not as readily interpreted as the requirements covered by other general type of plants, and only those guarantees should be made that can be carried out without question, and which cannot be misconstrued by the laymen who, when they are called upon to consider what may be classed as a public nuisance or menace to public health, may honestly differ with the engineer as to whether the results obtained are in accordance with the guarantees set forth.

The method of garbage disposal by the reduction process has been made a special study during the past year. In connection with this problem which confronts New York, the committee's opinion is that for large cities the revenue derived from the reduction process may warrant this method of disposing of the city's waste; but for small cities, it is agreed that the saving would not warrant the extra expense and risk of success of the reduction process. Sanitary conditions should be first considered, and it must be admitted that the destroying of refuse by heat is in general more sanitary than where assorting and working over the waste is required, which is usually necessary where reduction is considered.

During the past year municipal research as regards methods of refuse disposal, has rapidly advanced. As the result of continued study, it is predicted that fewer installations of modern destructors or reduction plants will be passed upon without a proper study of local conditions, and municipalities adopting same after this study has been made will not be disappointed. If there has been a lull in the adoption of modern plants, the time is near when, in our opinion, reaction will set in, and there will be a great impetus in the construction of same. Indications are evident that cities now studying the disposal problem are making a more thoro study than has heretofore been the case, and it is observed that where new plants have been installed, many engineers visit same.

Where the incinerator process is employed, not only is it necessary to adopt the proper type of plant for destroying the refuse, but there should also be considered the best method for conserving and utilizing the incinerator heat, which under favorable conditions, will go a long way towards paying the cost of operation of the plant. While the committee does not know of any new books having been published during the past year upon refuse disposal, there have been a large number of interesting and valuable articles published in the various engineering magazines, and many new data have been published in the reports made to a number of municipalities by consulting engineers, and by municipal research bureaus.

As to street cleaning, local conditions again have to be thoroly gone into before adopting the most economical and efficient methods for street cleaning. The flushing of streets, which is the most economical method of street cleaning, is only applicable to cities where the grades of the streets permit the street dirt being carried away in the sewers. Again the methods of street cleaning applicable for northern cities, where the problem of ice and snow is encountered, are not applicable to southern cities. The past year has been one of extensive study by many municipalities and engineers concerning the problem of street cleaning, and this study is bound to result in a decided advancement in the art and science of street cleaning.

Many municipalities have formed research bodies and the local governments of many of our moderate size cities are fast awakening to the fact that street cleaning is closely allied to public health, and this important work is being taken out of political patronage, and is being placed in the hands of experienced men and trained engineers.

The subject of street cleaning and the best means of obtaining satisfactory results from money expended is becoming of more interest to municipal officials and taxpayers than ever before and they observe that clean streets directly reflect upon the party in power. They realize that clean streets are one of the best advertisements that can be made.

The articles appearing in the various engineering magazines during the past year, show the rapid progress that is being made and the interest taken in keeping an intelligent account of the cost of

street cleaning. Unit cost data properly obtained with intelligent organizations of working forces result in increased efficiency and the saving of much money.

Advancement in the improved apparatus for street cleaning has been in the recent years very slow, and perhaps the most marked improvement made during this year has been the adoption in a number of cities of motor-driven street sweepers and sprinklers, and motor apparatus for handling material.

E. R. CONANT, Chairman, Savannah, Ga.

L. D. SMOOT, Jacksonville, Fla.

B. F. MILLER, JR., Meadville, Penn.

GUSTAVE R. TUSKA, New York City.

DISPOSAL OF GARBAGE, A LARGE CITY'S PROBLEM.

By Louis L. Tribus, Consulting Engineer, New York.

While a large city merely possesses more than a small city, of people having the same instincts and basic needs, the occupancy of greater areas brings perplexities of transit and complicates the catering to those desires and needs.

Necessities in the way of fuel, food and ordinary package supplies come first from many directions, reach many distributing points and are delivered by an army of agencies.

The materials for factory use and their attendant wastes do not as a rule cause much embarrassment, for even the wastes have sufficient value to call for care in removal; hence, so far as the municipality goes, are left to private attention.

Fuel, food and ordinary purchases result in ashes, garbage and rubbish; in each household of but small daily quantity and therefore of but little value, so that to get rid of it is the first thought and even to pay for so doing is not considered a burden.

There first grow up in cities, as they themselves grow, a group of small contractors who collect the wastes and dispose of them by dumping in vacant lots, low lands, etc.; but when the disposal places become scarce and health rules are well enforced, municipal aid is enlisted as opportunity for private gain lessens.

Ultimately great operating departments develop, to assume for the city at large the various functions and costs, and to relieve the individual property holder of the direct responsibility and expense. The tax bill replaces the twenty-five cents to a dollar a week contractor's charge, and economy or waste results according as departments are efficiently handled or are mismanaged.

The caring for the three main classes of waste, ashes, rubbish and garbage, involves three important factors; collection, transportation and disposal. Unless a city makes direct charge for the service, collection and transportation is an expense without effect. Disposal

may bring net revenue when intelligence, efficiency and regard for the city's purse prevail.

Ashes in Northern climes contain from 20 to 25 per cent of unburned coal as a general rule, but unless special facilities are provided for its re-use, its recovery for sales purposes is scarcely justified, unless the quantities are very large. It is a rare case where transportation costs would be low enough to warrant the gathering of ashes at one point in the large quantity needed to make economical the construction and operation of a sifting and washing plant.

Rubbish offers field for recovery of much of value. As an economic matter it should be resolved into assorted materials for sale and later manufacture into useful commodities. It possesses fuel value, though its bulk is out of proportion to the potential heat units.

Garbage, as ordinarily known, consists of household vegetable and animal wastes, rejections in the preparation of food and food not eaten. In general it analyzes into water, fat, bone, cellulose and a mixture of nitrogenous matters. From the fat a marketable grease can be obtained; from the vegetable matters, alcohol; and the residue serves as a rather poor base for fertilizer.

The complexity of plant and the expert attention required, make reduction of garbage a financial success only when quantities are comparatively large and the products therefore worth buying. We are dealing, however, only with the problems of large cities, so that all of the economies from process and quantity may be considered as available.

Plants for the treatment of garbage and in fact for any of the wastes, cost largely in the first instance. In the experience of the past, (and up to quite recent years, in fact), they have also been so attended by nuisance in operation, that city officials have been quite willing to dodge the responsibility of building and operating municipal plants. With, however, the accumulated knowledge from study, experiment, and practice of recent years, there is no further excuse for any large city to evade the issue and turn over to private interests any part of this peculiarly municipal function.

Unfortunately other factors do enter the case. Every administration of a great city has philanthropic friends who are quite de-

sirous of relieving the burdens of the refuse department, so, very self-sacrificingly offer private capital for the erection of plants in which to reduce the garbage to elements of value. In the past, they have usually been willing to accept payment for rendering such service, but latterly, out of the pure goodness of their hearts, they sometimes offer instead to pay real money to the city. Of course, this reduces their otherwise large prospective profits.

There is no valid legal objection to private parties rendering this service, provided all is done with honor, but there is usually no real need for any large city to thus turn over to others the only portion of wastes handling from which profit can be obtained. The act virtually robs the taxpayers of sometimes large sums of money.

A legislative iniquity often hampers the case also, making for larger expense to the taxpayer than necessary, in that many cities are debarred from entering into contracts for longer periods than ten years, and in some, as for instance New York, for only five. This means that a contractor must plan to amortize the cost of his plant within too short a contract period, tempting therefore to flimsy construction, poor repairs, cheap operation; all to make as much profit as possible and leave the least for later salvage. If he succeeds in getting a renewal of contract he goes on with a patched up outfit—almost sure to become a local nuisance.

It consequently is a city's duty, from the broadest standpoint, to render this community service at direct public expense; building substantially, giving adequate maintenance and operating in the best manner, so as to provide for the future as well as the present.

For many years German and English cities have largely adopted high-temperature incineration for all the wastes, using the steam power developed for operating the plants themselves and any surplus for sewage or water pumping or for electric light production; thus getting some positive return as a partial offset to the costs of collection and transportation.

In this country a number of successful similar plants have been installed, but official fear of hurting some corporate interest or the near-crime of a city going into business in competition with its citizens, has generally prevented full utilization of an incinerator's

output. Sometimes, alas, the lack of co-operation between a city's own departments is a preventive of efficiency.

In many cities the places at which collections are deposited before their transportation to final disposal points, have been almost unmitigated local evils; dust, odors, flies, etc., being largely in evidence.

Occasionally the wagon bodies are themselves transported without intermediate dumping, thus doing away with considerable nuisance. Of course, a clean, empty body must be waiting to replace the full one so as not to delay further collecting.

Transporting wastes of any class in open tank cars, or on scows has always been attended with at least sentimental objection, usually founded on valid grounds, particularly from late spring well into the autumn. Cities will rarely appropriate sufficient money to provide tight covered conveyors, and private parties cannot afford to under the usual terms of contracts.

If collection involves long haul after the cart or wagon is filled, large expense follows; if bulk transportation thereafter becomes necessary, additional expense is incurred, and the taxpayer pays all the bills. Now to what do all these facts point, if not to local treatment of wastes or at least of the nuisance-producing elements?

Experience has demonstrated that high-temperature incineration of mixed wastes, under proper municipal management, can be conducted without offense. Therefore such plants can be built and be operated within the producing districts, thus keeping collection at the minimum of cost and saving final transportation of sixty per cent in bulk, the final forty per cent of residue being innocuous slag.

Recent experiments in reduction processes indicate the feasibility of carrying them on without serious local offense, consequently the same possibility of disposal would obtain as with incineration; direct marketable by-products are the output, of very greatly diminished bulk and of a kind readily transported.

Adopting reduction as the process for garbage treatment leaves the ash and rubbish problems to be solved. There can, however be no good objection to a combination of methods by which the

rubbish and enough of the ashes to augment the coal supply could be used, saving the reduction process fuel bill and leaving the balance of the ashes for ultimate land fill as at present.

The ideal system from a sanitary viewpoint would be to have all garbage burned within the building in which it is produced and such actually is in effect in many hotels and apartment houses. This would, however, still leave the great bulk of rubbish and ashes for public disposition. Of course the aggregate costs of the gas, oil or coal fuel used, in thus locally consuming the garbage, would exceed that which would be necessary in large plants, hence it is an uneconomic tho a sanitary solution.

Some argue the greater economy and net return by using one great central disposal plant, but to those who realize that a large plant is no more than an aggregate of small units the point is not worth much. Given a collection of units to handle 300 to 500 tons of wastes per day under any process or combination of methods, it is possible to conserve practically all the economies of much larger plants; the by-products will be of sufficient bulk or importance to bring adequate return while caring for the garbage when fresh will relieve sanitary annoyance, and the saving in transportation expenses will largely offset the greater overhead charges and the somewhat increased expense in building several lesser plants in place of one large one.

In cities having river or tidal water fronts much valuable wharfage can be restored to other uses than dumping places, tho some wharves would still have to remain in service to care for the untreated ashes, the slag from the furnace and in some cases the residual products of reduction.

May we look forward to refuse treatment buildings taking their places in the civic centers with the Library and City Hall? Perhaps not quite, but when intelligent and efficient common sense, full consideration for the taxpayer's purse, and consistent engineering shall be united, we may almost reach that result, or at least bring them to the status of the less undesirable class of factories.

THE COLLECTION AND INCINERATION OF GARBAGE IN THE BORO OF SEWICKLEY, PA.

By Edward E. Duff, Jr., Boro Engineer.

The garbage disposal question has no doubt been discussed before this convention many times and it is not the intention in this paper to present any new theories on the subject, but rather to give the results of nine years' experience of the Boro of Sewickley in collecting and incinerating garbage, using a system of collection that satisfies the most exacting sanitary conditions at a minimum of cost and inconvenience to the householder.

In November, 1915, the writer prepared an article at the request of the *Municipal Journal* outlining the essential features of the system, so that some of the following data will be familiar to readers of that magazine.

The Boro of Sewickley, Pennsylvania, is a residential suburb of about 5,000 population, situated on the bank of the Ohio river, some 12 miles west of Pittsburgh, Pa., having an area of about one square mile, with a taxable property valuation of \$7,250,000. Prior to 1907 the garbage was hauled to the bank of a small run within the boro limits where it was carefully washed and subsequently buried. This system, as can be readily seen, was far from satisfactory, and the boro council took steps to relieve the board of health of their duties in this connection. A 12-ton incinerator was purchased from the Dixon Garbage Crematory Co., and erected in a suitable two-story brick building on property purchased by the council at one corner of the boro on the Ohio river bank. Subsequent to this action, it was decided to purchase sufficient cans to accommodate all the residences and to arrange for a system of collecting and incinerating the contents of the same.

To supply the boro, 1,357 cans are now in active use, 1,285 of which are at the residences, and 72 on one of the wagons as exchange cans. The cans are made of galvanized iron, weigh $17\frac{1}{4}$ pounds when empty, and have a capacity of about 11 gallons. They are ordered from the following specifications, which have been re-

vised from year to year as weaknesses have developed in any feature: $12\frac{3}{4}$ inches diameter by $19\frac{1}{2}$ inches high, 20-gage iron in body and bottom, 26-gage tight-fitting lid $1\frac{1}{2}$ inches deep, wrought iron hoops $\frac{1}{8}$ inch by $1\frac{1}{2}$ inches shrunk around top and bottom, heavy drop handles $4\frac{1}{2}$ inches from top. All cans and lids must be thoroly galvanized and be guaranteed against leakage. These cans are purchased in lots of 200 to 400 each year at prices varying from \$1.00 to \$1.60 each, depending on the current prices of the raw materials. The cans are subjected to hard usage and our records show their life to be from $3\frac{1}{2}$ to 4 years. One of the main sources of damage is due to householders using the can as a convenient place to burn waste paper.

The cans are placed by the collectors in any location convenient for the householder, and while their use is primarily for garbage, all kinds of refuse is found in them, such as paper, bottles, cans and even occasionally a dead cat.

Two specially constructed wagons, carrying 72 cans each, were built by the boro for the collection of the garbage. The wagons consist of a flat bed or floor set above wheels, about 4 feet above the street level, and having a few uprights around the sides to which chains are fastened to prevent the cans from falling off. The cans are placed in six rows with twelve cans to a row and as the empty cans are taken from the wagons to replace the full cans, the driver or the collector shifts the remaining empty cans to the outside.

Collections are made once each week in the residence districts, except during the summer season when there is an unusual amount of vegetable refuse, such as corn husks, watermelon rinds, etc., when three collections are made in two weeks. The hotels, restaurants, hospital and other places where an unusual amount of garbage is found have two collections each week. From one to five cans are left at each residence and as many as eleven or twelve cans at the hospital and hotels, depending, of course, on the actual need and the garbage accumulating. We have found that two cans per week give ample accommodation for the average family, and where it is necessary to supply more than two cans, the additional cans must be purchased by the householder, and these, of course, are exchanged the same as those owned by the boro. In collecting, the lids are not removed from the cans from the time they leave the residence until



1. General Location Picture, Sewickley Garbage System. Showing Garbage Furnace on Left. Stables on Right. Wagons on Platform between Furnace and Stables. Coal Storage under Platform.

they reach the furnace, and there is consequently no nuisance created emptying from one can to another or from the can to a wagon. The lids fit tight, and the cans are kept so clean that there is little or no odor about the wagon. The usual unpleasantness generally associated with a garbage wagon, such as the rattling and banging of cans and the slamming of the doors on the familiar steel wagon, is conspicuous by its absence, and had you not been previously informed, I doubt if many of you would associate the wagon and equipment with the garbage work.

Our present needs require the use of only one team of horses and one wagon in the collection work, the second wagon being loaded at the furnace for the next trip. In charge of a driver and collector, both of whom, however, act as collectors when necessary, each taking one side of a street, the wagon makes four trips per day, bringing 285 cans to the furnace, having a total average net weight of 4 tons.



2. Sewickley Garbage System. Showing Cans on Wagon just as they arrive from collection trip. Wagon on right about to start on collection trip.

This is at the rate of 85,540 cans per year, having a weight of 1,200 tons. An additional ton of garbage is received each day in bulk from the grocery and fruit stores, making a daily incineration of 5 tons and a yearly incineration of about 1,500 tons.

The boro is 1 mile long and approximately 1 mile wide, so that in going from the garbage furnace to the diagonally opposite corner of the boro, the garbage wagon covers on the round trip about 3 1-3 miles, making collections, however, for only $\frac{3}{4}$ of a mile in this distance. The shortest route is $1\frac{1}{4}$ miles and collections are made for only $\frac{1}{2}$ mile before the wagon is loaded. Due to more convenient locations of the cans in the first mentioned district, the trip is completed in 2 hours, while it requires $1\frac{1}{2}$ hours to do the work on the short trip. Eighteen routes are covered by the wagon in $4\frac{1}{2}$ days, in which time one collection is made thruout the boro. The remaining day and one-half is used making the second collection for the week in the business district.

Upon arriving at the furnace with a load, the wagon is left in front of the big door of the furnace building, and while the driver

is hitching the horses to the extra wagon, which has previously been loaded with clean empty cans, the collector assists the furnace man in emptying the garbage into the incinerator until such time as the driver is ready to leave, which is usually about five minutes.

During the winter months when the wet garbage is frozen, we find it necessary to thaw the garbage before it can be emptied from the can. A short application of a jet of steam from the hot water heater will allow the garbage to be removed. The use of bars or hooks for the purpose is prohibited because of the damage likely to occur to the cans.

In the period of $1\frac{1}{2}$ to 2 hours usually elapsing between loads, the furnace men allow fifteen minutes to empty garbage into the furnace, twenty minutes to wash the cans, and twenty-five minutes to load the 72 cans on the extra wagon and arrange it for the next trip. The remaining time is spent firing the furnace, hauling ashes, etc.

Coal is used in the furnace to burn the garbage, while coke is burned in the flue to complete combustion. Altho the garbage plant is located within 300 yards of some of the best residences, there is no complaint at any time of objectionable odor.

All the cans are thoroly cleaned with scalding water before they are again placed in active use. Five cans are placed on a rack at one time, and after they are thoroly clean, they are placed on the wagon for service. It is very seldom that complaints are received regarding dirty cans, yet most householders do not realize the work required to clean a can that we have received probably half full of dough or some other equally adhesive "left overs" from the kitchen.

The total investment, exclusive of real estate, might be distributed as follows:

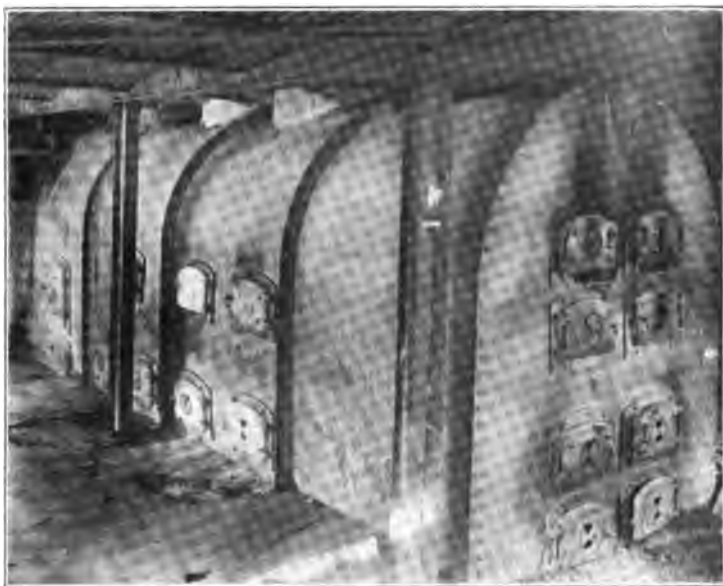
Building, driveway, platform and incinerator.....	\$ 8,500
Stable	2,000
Two horses and harness.....	700
Two wagons	400
1,357 Cans, at average price, \$1.25.....	1,696
Total	<hr/> \$13,296



3. Sewickley Garbage System. Showing method of emptying cans from wagon into charging hopper of incinerator. Two charging hoppers in floor in foreground. Hot water heater in corner. Flue from incinerator at left of hot water heater. Four of the five can washers at left of picture. Two cans on the washers, and two washers exposed.

The average of the yearly charges for the past eight years and ten months to January 1, 1916, as taken from the annual report of the boro clerk, show :

Wages (driver, collector, two furnace men)	\$ 2,699.22
Coal and coke (about 650 tons per year)	651.81
Freight on coal, coke, firebrick, etc.	330.40
Repairs (relining furnace, grate bars, etc.)	257.40
Insurance (fire insurance on buildings and platform) ...	33.96
Horse feed	389.86
Blacksmithing	104.26
Cans	313.43
Extraordinary expenses (rebuild driveway and platform, etc.)	76.57
New horses	92.24
Credit (sale of cans and coal)	33.15
Total average cost per year	\$ 4,997.98



4. Sewickley Garbage System. Showing at right of picture, the firing and ash doors of the incinerator. Coal storage at the right (not shown in picture). Doors in two center panels for spreading garbage and removal of garbage ash. Doors at extreme end of incinerator for coke fire, burning in flue. Hoppers from charging floor shown at top of two center sections of incinerator.

Of this total amount, one-half of the cost of wages (2 men), all of the coal and coke; 90 per cent. of freight charges, 90 per cent. of repairs, all insurance, 10 per cent. of blacksmithing and one-half of the miscellaneous, making a total of \$2,616.81, are charged entirely to incineration, leaving a balance of \$2,381.17 as the cost of collection. This amount is raised by about seven-tenths of a mill tax on the valuation of \$7,250,000.

On the basis of the above figures, and exclusive of any interest on the investment or sinking fund charges, it has cost us \$1.00 per inhabitant per year to collect and incinerate the garbage, of which amount 52 cents was spent for incineration and 48 cents for collection. On the basis of 1,500 tons per year, it has cost \$3.33 to collect and incinerate each ton.

The incineration of the garbage is not new to any of you, but the question of collection has, no doubt, bothered many municipal officials. The best is none too good when one is planning an efficient

sanitary garbage system, and the benefit derived from a successful incinerator may readily be counteracted by an inefficient, unsanitary system of collection. In Sewickley the residents are relieved of all responsibility regarding the purchase of cans and payments for collection. There are no unsanitary garbage wagons clattering over the streets, and there is no trail of garbage drippings from the back yard to the front street. Of course, any system will meet with objections from a few unreasonable people, but we feel that we are giving the best service in the best manner at a minimum cost, and while our system is small in proportion to the needs of many towns or cities, I feel sure that, with proper management, the principles applied in the Sewickley system would be applicable in places many times the size.

HORSE VS. MOTOR FOR GARBAGE COLLECTION.

By B. F. Miller, Jr., City Engineer, Meadville, Pa.

In this age of the motor, when almost every day develops some new use for its power, one might quite naturally imagine that in the collection of municipal garbage and refuse the sooner the horse-drawn vehicles were discarded the better.

However, an investigation of this subject in 125 American cities discloses the fact that there is still much to be said in favor of the horse, especially in the matter of garbage collection.

The writer, in submitting this report, has given the arguments pro and con, which were received in response to a circular letter sent to 225 American cities, from which about 125 replies were received. It will be noted that comparatively few cost data have been received, due primarily to the fact that so few cities have used motor apparatus (105 are still using horse-drawn apparatus), or that some of them have not used them long enough to have collected any data of value. The replies received showed an awakened interest among municipalities in the following:

1. A growing tendency toward placing garbage collection under the active supervision of departments of public works, as opposed to supervision by health boards.
2. A decided sentiment in favor of municipal collection instead of the prevailing contract system.
3. An awakened interest in the serious study of garbage collection and disposal, as, for example, the excellent report of Mr. I. S. Osborn on the collection and disposal of garbage for the District of Columbia.

Briefly summarized from the replies received, the principal arguments for the use of motor-driven vehicles for garbage collection, are as follows:

1. Where the garbage can be delivered to a central unloading station and then taken from this point to the disposal plant with

motor vehicles, there is, no doubt, much economy in the use of the motor. However, the practicability of a central station is somewhat doubtful, for it would, to be of advantage, have to be located in a somewhat populous district, and several cities, notably Seattle, who have tried this plan have discarded it because of the serious objections of people living in the neighborhood of the central station. If some means of eliminating the objectionable odors at the central station were devised, possibly it might become practicable. Of course, with such a station the hauls of the horse-drawn wagons would be shortened and much time would be saved in not having the collectors make the trip to the disposal plant.

2. Los Angeles reports that motors, in residence districts, are advantageous over teams because collections can be made more regularly, and that motor collection is at least as cheap as horse collection under similar conditions. They are using two $2\frac{1}{2}$ -ton trucks for garbage collection in their residence district. The first collection is 8 miles from the reduction plant. The cost of collection and delivery to the plant by motor is \$2.75 to \$3.00 per ton; by team it is \$2.37. The trucks are operated by one driver and two collectors and make two loads per day. Each truck travels from 20 to 40 miles per load collected and works 8 hours per day. In the same district a team of 3 horses and driver made 1 load per day, wagon hauling $2\frac{1}{2}$ to 3 tons per load and trucks $2\frac{1}{2}$ to $3\frac{1}{2}$ tons. The cost given above includes maintenance, depreciation and interest. The cost data for horses included depreciation for stock, but no account was taken of extraordinary wear on stock due to long hauls.

3. Pasadena reports using a 7-yd. truck costing \$2,450 for refuse collection. The life of the truck is 5 years and costs \$7.11 per day to operate, exclusive of depreciation, but including oil and distillate. This truck averages 42 miles per day, hauling 16 cu. yds. average and replaces two 2-horse and two 1-horse wagons. The two 2-horse wagons covered 20 miles per day and the two 1-horse wagons covered the same amount. The truck requires 2 men to operate, while the wagons require 4 men and six horses.

4. Spokane reports that for residence districts, long hauls and heavy loads, one truck takes the place of 4 teams.

5. Tampa reports a 50 per cent. saving in the use of the motor

truck, in replacing horse-drawn apparatus, for partial collection only. In street-cleaning apparatus a 50 per cent. saving was effected. No figures were given to prove this statement.

6. Detroit uses motor collection from hotels and restaurants, and also from central collection station.

7. Joliet, Ill., uses motor truck from central station.

8. Brockton, Mass., Montgomery, Ala., Paterson, N. J., and Augusta, Ga., have discarded horse-drawn apparatus and installed motors for house-to-house collection, but are not yet ready to report cost data.

9. The Norfolk Navy Yard expects one motor truck to replace one 2-horse and three 1-horse teams.

10. Buffalo is considering central collection depots and motor delivery from this point to the disposal plant.

11. Nashua, N. H., collects rubbish with a truck and finds that one truck does the work of from 2 to 3 teams and shows much economy.

The objections to motor apparatus as given were as follows:

1. The speed gained on the long hauls is more than offset by the time consumed in getting on and off the truck while loading.

2. With a truck a driver would be necessary all the time in addition to the other operators, thus adding extra cost, while with horses a team or single horse can be trained to move from house to house at a call from the driver, who also collects the cans.

3. Either the life of the motor will be shortened due to many stops and starts or, if the engine is allowed to run, excessive use of gasoline results.

4. Many cities place refuse in sanitary fills and motors are not practical in low marshy ground.

5. The cost of motor equipment is considered by many to be prohibitive.

6. The Denver Hog Ranch Co., which collects garbage for the city of Denver, says: "We are using teams to collect garbage from the city of Denver in preference to trucks, our haul being 5 miles.

The rainfall in this country is only about 13 to 15 inches per annum, consequently the roads are usually in good condition, except perhaps for a short time in the spring. We have gone over the truck proposition several times with different salesmen, who had an idea they could save us money on the collection and removal of the garbage, but it is our conclusion after careful investigation that the only way a saving might be made would be to have all the garbage collected and removed to a central point and then hauled from the central point to a place of disposal.

7. Motor vehicles are not adapted to pick-up work.
8. In northern climates, where heavy snows are prevalent, motor trucks are not suitable even for long hauls.
9. Syracuse, N. Y., is discarding trucks for house-to-house collection, and using them for hauling from a central station.
10. Toledo has discarded trucks on account of heavy grades and rough roads.
11. Dayton experimented with one truck in house-to-house collection and found that it did not pay. The cost to collect with truck was \$1.37 per ton, as against \$1.09 for horse collection.

• CONCLUSION.

From the above replies the following conclusions may be drawn:

1. Motor vehicles are not practicable for house-to-house collection of garbage, except perhaps in a few instances where residences are far apart, as in Los Angeles or Pasadena.
2. Where it is possible to establish central stations (and there does not seem to be a very immediate possibility that they will become very popular) the motor will prove an economy for the long haul.
3. In refuse collection motors show considerable economy.
4. In downtown districts it would appear that better service, even tho not as cheap, might be gotten from trucks in collections from hotels and restaurants.
5. Horse-drawn apparatus seems most suitable for house-to-house collections, and for delivery to central loading stations.

THE NEW GARBAGE REDUCTION PLANT FOR THE CITY OF NEW YORK.

*By Gustave R. Tuska, Consulting Engineer, Lecturer on Municipal
Waste Disposal, Columbia University, New York City.*

The city of New York is now engaged on the construction of a new reduction plant for the final disposition of all the garbage collected in the boros of Manhattan, the Bronx and Brooklyn. The capacity of this plant will be over 2,000 tons of garbage per day. It will therefore be the largest plant of its kind in the world and its construction will be of further interest in view of the fact that every possible improvement in the handling of garbage will be installed in this plant, so as to enable the disposition of the garbage to be done in a thoroly sanitary manner.

The most important consideration in the design and construction of this plant has been that it shall be built and operated after the most sanitary methods, and the matters of first cost and cost of operation have been secondary considerations.

This plant will be located on Lake island in the town of Greenridge, Staten Island, at the junction of Little Fresh Kill and Great Fresh Kill, about a half mile from Arthur Kill or Staten Island Sound. It is being constructed and will be operated on its completion by the Metropolitan By-Products Company.

The process to be used in this plant is that known as the "Cobwell process." There are already two plants in successful operation using this system, namely, that handling the garbage of the city of Los Angeles, Cal., and that of New Bedford, Mass. Both these plants have been in operation for some years, in the course of which the success of the process has been absolutely demonstrated.

The method of reducing the garbage under the Cobwell system is as follows: The raw garbage is placed in a closed tank called the reducer and covers are placed thereon and sealed air-tight. This reducer is a cylindrical digester 8 feet in diameter and 4 feet high. It is constructed with jacketed walls and jacketed bottom. Into

these jackets the steam which is used in the reduction of the garbage is delivered. The design of these jackets makes it impossible, under proper operation, for the steam to enter the tank or come in contact with the garbage. In the interior of this tank there is an agitating device operated by power from the exterior. When the proper charge of garbage has been placed in the reducer and the covers are placed thereon, the tanks are sealed and the solvent is pumped into the reducer and steam is admitted to the jacketed walls. The heat from the steam, which is transmitted to the garbage thru the walls of the reducer, causes the evaporation of the solvent and the water in the garbage.

Garbage is usually composed of over 70 per cent. by weight of water. The steam heat vaporizes the solvent and the water from the garbage, and these mixed vapors are drawn off from the reducer to a condenser. The economy in this method of evaporation rests on the fact that water is vaporized at a lower temperature when evaporated with a solvent having a low boiling point than when evaporated without such solvent.

The mixed vapors of the solvent and the water while in the condenser are then condensed to a liquid state and the water and solvent together are conveyed to a closed tank. Owing to the solvent being of lighter specific gravity than the water, the solvent and the water are separated by gravity, the solvent rising to the top, from where it is drawn back to the storage tanks, from which it is pumped back to the reducers and used over and over again. The condensed water, which has been largely diluted owing to the jet condensers used, is discharged into sewers or waterways.

When the garbage has been thoroly dried by this method, the solvent is pumped into the reducer and dissolves the grease. The solvent with the grease is drawn off into a closed tank or evaporator, where the same is heated by steam pipes, where the steam is kept separated from the grease. The solvent therein is vaporized and carried to a condenser where the same is again liquefied and carried to the storage tanks to be used again.

After the grease has been extracted from the garbage in the reducer, it is further dried by means of the steam in the jacketed walls and is now in the form of degreased garbage tankage which is used for fertilizer purposes after being ground and screened.

It will be seen from the above description of the process, that if there are any leakages or vents in any of the tanks or piping where the solvent is handled, more or less of the solvent is lost, and thereby a substantial additional expense is imposed upon the operation of the system. Furthermore, under this system, the garbage is at no time brought in contact with the atmosphere from the time of its original entrance into the reducer until after over twelve hours of cooking, it is finally discharged therefrom as finished products, dried, sterile and practically odorless. These finished products are grease and the tankage above referred to.

It will be seen from the above description that the process is one of straight de-hydration and from the time that the material is at the boiling point no further chemical action in the material takes place. No process of "digestion" occurs and therefore the odors and gases incidental to such a process are not created. Only the volume of gas contained in the raw material is driven out and only the essential oils of an extremely volatile nature are carried over in the current of steam and solvent vapor evolved. That little or no conversion takes place in the operation is shown by the fact that in the de-hydrated material obtained at the end of the operation, there exists practically the same amount of unconverted starchy bodies as existed in the garbage at the time of its entrance into the reducer. The water condensed contains all the gases evolved and has, when fresh, a slight odor of the mixed essential oils. Some traces of alcohol are detected in the effluent and a very small quantity of fixed oils is carried over. Any ammonia evolved, if it has escaped the acid in the garbage, is neutralized by acid carried over in the vapor. Whatever albuminoid ammonia exists in the effluent is carried over by mechanical entrainment as dust particles during the period of the steaming out of the solvent.

The effluent from the plants employing the Cobwell process consists of almost pure water, this water being the condensed moisture drawn from the reducer while the garbage is being treated and from which the solvent has been extracted as completely as possible.

An analysis of the undiluted effluent, being an average sample of a day's run at the New Bedford garbage plant, is as follows:

Acidity calculated as acetic acid.....	.05%
Total solids .....	.10%

Oxide of iron (included in solids) .....	.053%
Total nitrogen as ammonia .....	.0031%
Albuminoid ammonia .....	.00012%
Fixed and volatile oils .....	.0059%
Organic solids .....	.033%

The effluent after being exposed to the action of sun and air for thirty days gave no evidence of putridity but did have a slight vinegar-like odor. At the time of flowing from the separating tanks, where the solvent is recovered from the condensed mixture of water and solvent, there was a slight sweetish acrid odor, resulting apparently from the mixture of essential oils and petroleum. This effluent is cold and gives forth no steam or vapor and the odor can only be located by coming within 2 or 3 feet of the flowing water before the same has been diluted.

The total amount of such effluent can be reckoned on the basis of 1,400 pounds to each ton of garbage handled. On this basis, the New York plant will, from 2,000 tons of garbage, produce 340,000 gallons of effluent of this concentration per day.

Calculating the total materials passing off in the effluent, we have

Total solids	2800	lbs.
Total ammonia	86	lbs.
Albuminoid ammonia	3.6	lbs.
Organic solids	924	lbs.
All these included in total solids.		

It must be understood that the above figures are based on the undiluted effluent or the actual water contents of the garbage condensed in surface condensers. In the New York City plant, jet condensers will be used. In these the condensate and the condensing water are intimately mixed and the dilution is very large—about 20 parts of cooling water are necessary and the consequent dilution of 1 to 20 results in an effluent without any perceptible odor and an extremely low solid and ammonia content.

Effluent from an experimental jet condenser employing water from city mains and not sea water, as will be used in the New York plant, showed the following analysis:

Total solids .....	.01%—100	parts per million
Organic solids .....	.0048%—	48.4 parts per million
Mineral residue .....	.0052%—	52.5 parts per million
Total ammonia .....	.00024%—	2.4 parts per million
Albuminoid ammonia .....	.00005%—	.5 parts per million
Oxygen requirement		22 parts per million

It is impossible that an effluent of this concentration can have any undesirable effects when run into a large body of water. Rarely does the effluent from modern sewage disposal systems show so low an analysis of undesirable bodies.

The only other possible source of odor during the entire reducing operation would be from the odor contained in the air and gases mechanically included in the green garbage prior to its entrance into the reducer. These gases, plus the air in the reducer itself at the time of filling, are driven out by the first rush of solvent vapor. Only one small vent is provided in the entire plant for the escape of these gases with any possible odor which they may carry. This vent is located on the storage tank for the solvent. The entire volume of such gases resulting from the handling of 2,000 tons of garbage in 24 hours would be but 50,000 cu. ft. At the plants now in operation, the only odor detected at this vent has been that of petroleum, which either destroys the possible vent gases or else masks them.

As regards any odor from the tankage, when this material is taken out of the reducer, it is in a dry condition and very warm and when it is first exposed to the atmosphere there is momentarily a slight odor of dried material best described as a smell of stale gingerbread, due to the essential oils rising from the material when hot. No gases are generated and this odor lasts only during the period of dumping and is not perceptible outside the building.

It will be seen that in the operation of garbage treatment by the process to be employed in this plant there is no period of gas generation and no large volume of decomposition and combustion gases given off as in digestion and drying. There is, therefore, no necessity for condensing, washing, or trapping odors or gases.

DESCRIPTION OF THE PLANT.

At this plant the garbage will be delivered in barges, so constructed that all water drained from the garbage in transit will be collected in a special closed tank located at one end of the barge. On the arrival of the barge at the plant these tanks will be automatically emptied by attaching a steam connection thereto and by means of the steam pressure blowing the drained water to tanks on shore; the steam also acting so as to disinfect the tanks. While in transit the barges will be covered by specially treated waterproof canvas covers so attached as to prevent the discharge of any of the garbage from the barges.

A canvas apron will extend from the barge to the dock to prevent any of the garbage falling into the water during the unloading of the barge. This apron is so designed that it will automatically move with the barge when the same is moved along the bulkhead to bring the various portions of the load under the hoist.

The garbage will be unloaded from the barges by two steam-operated hoists, equipped with grab buckets. These grab buckets will deliver the garbage to closed conveyors of the steel scraper type, which will convey the material to the reducers, located in the main building.

This main building is 200 feet by 330 feet and about 30 feet high and of one story. This building contains the reducers, 250 in number, with the necessary conveyors (all of which will be of closed type) for the raw garbage and for the dried tackage, also the piping for steam and solvent and the transmission machinery. The capacity of each reducer unit is from 8 to 10 tons of raw garbage per 24 hours, depending on the steam pressure employed. In the New Bedford and Los Angeles plants the capacity obtained from one unit is 8 tons per 24 hours, with a steam pressure of 70 pounds. Here the steam pressure has been increased to 150 pounds, thereby raising the temperature for de-hydration from 320 degrees F. to 360 degrees F., thereby increasing the capacity of the reducer. An increase in the capacity has also been obtained thru the change in solvent. In other plants using this process gasoline is employed, but in this plant there will be used a special solvent, which is a kerosene distillate obtained by use of a vacuum still, which distillate will be

made at the works. A further economy will be obtained by so designing the circulating system as to return condensed water at 360 degrees F. to the boilers.

Heretofore only surface condensers have been employed in the plants using this process, but after a considerable amount of experimental work with jet condensers, it has been proven that the latter are more satisfactory as well as more economical. It has, therefore, been decided to use the jet type of condenser in this plant.

The grease with the distillate is piped from the main building to the stills, which are of the vacuum type, and the distillate is there taken from the grease, condensed and delivered to the solvent storage tanks and the grease to other storage tanks. The "grease" building where this work is done is 100 feet long by 100 feet wide and 25 feet high. The dried tankage is conveyed by belt conveyors from the main building to the grinding and screening buildings.

Pan mills and rotary screens are employed. From the screening building the tankage is conveyed to the storage building, which is 100 feet long by 100 feet wide and 40 feet high. The material is distributed thruout this building by screw conveyors. Two tunnels will be built thru this building, containing belt conveyors to automatically convey the stored material to the loading vessel thru swivel spouts.

The boiler house with an engine room extension will be 140 feet long by 50 feet wide and 65 feet high. Water-tube boilers with automatic under-feed stokers will be used with a productive capacity of 7,500 boiler horse-power.

The plant will also comprise a machinery building 30 feet by 160 feet by 25 feet, containing pumps of a capacity of 21,000 gallons per minute. Also boiler, blacksmith, machine and pattern shops and storeroom, etc.

The storage tanks will have a capacity of 400,000 gallons of solvent, and 14,000 barrels of grease. There will also be constructed the necessary administration building; mechanics' dormitory building, etc., etc.

The estimated cost of this plant when completed for a capacity of 2,000 tons of garbage per 24 hours is \$3,000,000, the main items of which are as follows:

Buildings	\$ 500,000
Boiler plant, including concrete stack.....	190,000
Reducer units, including condenser, still and auxiliary equipment, at \$7,000 each for 250.....	1,750,000
Piping	250,000
Conveyors	125,000

From the above it will be seen that this plant figures out a total cost of construction of about \$1,500 per ton of garbage per day. The cost of a similar sized plant operating by the digester or Arnold system will figure out about \$1,000 to \$1,200 per ton of raw garbage per day. It is therefore evident that a plant operating on this process is from 25 to 50 per cent. more expensive than one on the digester system. The cost of operation per ton of garbage by this system is also considerably higher than by the digester system, the labor cost being about the same, but the cost for fuel and solvent being considerably greater.

As against this increased cost we have superior sanitary advantages and a considerably greater value of recovered products. By the use of this process a larger grease recovery is obtained, also a more valuable tankage. When the digester system is employed, the potash contained in the vegetable fibre, being soluble, is lost in the discharged water. With this process it remains in the tankage, amounting to over 1 per cent. by weight in the dried product.

Furthermore, with the digester system, the largest portion of the water contained in the garbage is removed by pressing. This water discharged from the presses carries 8 per cent. of solids by weight and is the most valuable for fertilizer purposes, as it contains all the ammonia and potash which is water soluble. All such material is recovered by the Cobwell process.

Furthermore, with the digester system, where direct heat driers are used there results a large loss of solids (takange, grease and fibrous material), averaging about 20 per cent. of the total weight of tankage fed into the dryer. This loss is due to carbonization of the materials named and results in various odors and gases. This loss, with the resultant gases, is avoided by the process to be used in this plant.

As before stated, the capacity of this plant has been specified at

2,000 tons of raw garbage per day. According to the official data the total amount of garbage now collected and delivered by the city is about 400,000 tons per year and the yearly increase is at the rate of about $2\frac{1}{2}$ per cent. The average amount collected daily is about 1,300 tons and the maximum daily collection is about 1,600 tons.

DISCUSSION.

MR. BROOKS: I should like to ask the last gentleman who spoke if it is possible that New York, after paying the expense for collecting the garbage from the time it leaves the households down to the island and the expense of reducing it can make money on it as a whole? In other words, will the products of the reduction plant go anywhere near paying for the entire disposal of the garbage from the households?

MR. TUSKA: I will say in answer to the gentleman's question, that the present situation in New York is as follows: New York City has called for bids for the disposal of its garbage for five years, the contractor to build and operate the plant and the city to deliver the garbage on board barges at the wharves in New York City. One condition of the contract is that the plant shall not be built in the boro of Manhattan or in Jamaica Bay. Now this means, therefore, that the city will deliver the garbage on the barges of the contractor, and the contractor will transport it to the plant, wherever it will be located, and then the contractor will own whatever products are obtained from the transported garbage, that is, grease, tankage and sorted materials. The letting of this contract by the city results in the city being paid in five years by the contractor the sum of \$900,000 in cash for the privilege of having the garbage delivered to the scows at New York City. You may know that some years ago the city had to pay for the reduction of this garbage. Then gradually as the values of the by-products increased, and as the public became aware of what the value of these by-products was, parties were willing to pay for the garbage, and the city, instead of paying as it did fifteen or twenty years ago for handling its garbage, is now being paid for it by this contractor nearly \$200,000 a year. Of course, no contractor is going to pay the city \$900,000 in five years unless he believes he is going to make money from the reduction of the garbage. As to whether the pro-

ducts recovered would pay for the collection expenses, that is another question. In New York City the cost of collection is very high because we have an enormous area and in some cases long hauls. It is, of course, a matter of public record as to what the collection of garbage costs the city, but furthermore it should be borne in mind that a contractor who has only a five-year contract for this work must write off the cost of the plant in the five years that his contract has to run. If, on the other hand, the city owned the plant it would not be necessary to write off the plant in so short a time. So the yearly profits to the city would be much larger than to a contractor who only has a five-year contract for this work. My opinion is that generally the profits from operating the plant would pay for the collection, if the city operates the plant as economically as a private party would do.

MR. TRIBUS: On this Staten Island project I will say very little, for I am in a very peculiar position. The Street Cleaning Commissioner of New York City, who has let the contract, is a special partner in my own firm, and yet I have been fighting the proposition that Mr. Tuska has described so clearly, from the very first moment that I knew of it, trying to prevent its consummation. for two reasons: The first, as a resident property owner of Staten Island, I am opposed to having the burden of caring for the wastes of the three big boros of the city, as an unfair proposition; and second, it is an unnecessary solution of the problem. The whole Staten Island population has felt justified in opposing it, altho there are some merits in some features of the plant as designed. But the main point that I wish to call attention to is this: Almost all large cities are afraid to meet the proposition of caring for their own wastes. They charge to the taxpayers all of the costly operations of the work, collecting the refuse and carrying it to some point, and then give to the contractors the velvet, the grease. The contractors make the profit, instead of the cities taking up their own responsibility and conserving the purses of the taxpayers. Now this Staten Island contract calls for the payment to the pension fund of the street cleaning department during the course of five years the sum of \$900,000. Nine hundred thousand dollars is a mere bagatelle compared with the loss or depreciation in taxable valuation to the city, due to continuing in service insanitary dock dumps, and the injury to property, sentimental injury if you please,

that will come from the gathering of a large quantity of refuse at one point, designating such a locality as a region for wastes that generally are considered as public nuisances.

With the present knowledge as to handling garbage, two methods are practically feasible if proper plants are provided and proper management goes with them. High temperature incineration, which will give perhaps the least direct returns, and reduction, which gives the greatest return. Both processes can be carried out in suitable plants near or in the localities from which the refuse emanates. Ten plants of 200 to 350 tons per day will give, as far as the return goes on operation, practically as much revenue relatively, as one plant of ten times such capacity. The first construction cost is obviously greater; the overhead charges are somewhat greater. But there are other attendant advantages, of short haul, caring for the refuse while it is fresh, and the fair-play proposition of having each locality take care of its own waste. Now, underlying the whole principle is this: Not whether a city is going to get so many dollars in return, but the sanitary feature should be paramount, to get rid of these wastes in the shortest order with the lowest proper expense.

MR. TUSKA: I fully agree with Mr. Tribus, that the most important consideration in the construction of a plant of this kind is whether or not it is sanitary; that the question of cost of operation or cost of construction should never be considered until it has been absolutely settled that the plant will be sanitary and that the material will be taken care of in a sanitary manner. I do not want to be misunderstood here as holding the position that the question of profit or loss in the construction or operation of a plant of this kind should be considered for one instant, either by the city or any one else who is passing on it, in advance of the sanitary question. The first question is that of sanitation, and on that I think the previous speaker and I agree.

Now, as I understand the previous speaker's remarks, what he is proposing is the idea that the city should have a large number of plants distributed thruout the city, and each plant taking care of the garbage in its own vicinity. Is that correct?

MR. TRIBUS: Yes.

MR. TUSKA: Now I agree with the previous speaker that the most sanitary method of handling this material would most likely be to dispose of it before it left the locality where it was made. I will go a step further than Mr. Tribus, and I would say, why collect it at all? Why not have it disposed of, if it could be done in a sanitary manner, on the premises where it is produced? Why have it removed from the premises at all? And that is today the disposal method employed in many cities and in many large buildings, especially hotels in New York City and in other similar cities. But it happens that that is not feasible in most places because you have a large number of small dwellings or small householders who would be indifferent as to whether this material decomposes and creates odors, and therefore, as a protection to the people the city itself must in some way take care of this material in a sanitary manner.

Furthermore, we have seen here in connection with the construction of the New York plant, strong opposition raised by the residents of Staten Island—and I do not say unjustly—and they have succeeded in delaying the construction of this plant a great many months, and very likely will find methods to further delay the operation of this plant for some time. The people are undoubtedly sincere in their opposition. But assuming that this plant will create no offensive odor, assuming that this plant will create no conditions detrimental to health, and it is my firm belief that such will be the case, you still have a strong sentimental objection to the installation of any garbage plant. And that is possibly the strongest objection, and one of the most important considerations when you locate a plant of this sort in any place. Now, when we are having such strong opposition here to the construction and operation of this plant, which promises to be a sanitary one and not likely to create a nuisance, and further consider the strong sentimental objection to the installation and operation of any garbage plant near any village, what would be the situation if in a city like New York you were to divide it up into a large number of districts and attempt to put up, instead of one plant, possibly 20 or 30? What locality would want a garbage plant installed there no matter how sanitary its construction and operation would be? What district would want a garbage plant placed right there in its midst? You will have objections from every part of the city just the same as we now have at Staten Island. And even tho you prove that the operation will

be sanitary there will still be the strong sentimental objection to the installation and operation of a plant of this kind. The city but a short time ago intended to build a plant at Rikers Island on its own property, which plant the city was to ultimately own and operate itself. New York City was to pay for the cost of this plant at the end of five years, during which time the contractor was to operate the plant. The objections raised by the residents of the boro of the Bronx, altho some miles from the location of this plant, were so strong that the city was compelled to give up the plan, and, as I have said before, you would have similar objections raised in every part of the city so that you could never build any plants at all. Furthermore, when a city operates a plant it must look mainly to the sanitary side, and as a secondary consideration, to the loss or profit in the operation of such a plant. In the last fifteen years I have been associated as consulting engineer with many large reduction plants in this country, some operated by municipalities and some by private contractors, and my experience, corroborated by the published reports of municipally operated reduction plants, has shown that where municipalities have operated their own plants they have always been less profitable than when operated by private parties. To you who are familiar with municipal affairs this is no surprise, as you are undoubtedly aware that economies are always greater where the operation is conducted by private parties than where it is conducted by municipalities.

MR. OSBORNE: There is one point that Mr. Tuska might have brought out, and that is on the cost of handling by the municipality as against the contract system. It is a question in my mind whether a contractor can operate for the city at a less cost than the municipality can itself.

SOME PUBLIC HEALTH ASPECTS OF REFUSE REMOVAL.

By Charles Saville, Director of Public Health, Dallas, Texas.

The purpose of this paper is to present briefly a few of the public health aspects of refuse removal, including the preparation of the refuse at the house. No attempt is made to discuss methods of refuse disposal.

Kitchen garbage, or "swill," so-called, consists of waste food materials of animal and vegetable origin. It decomposes readily, and on becoming putrescible emits offensive odors. Garbage is likewise a favorable breeding place for flies, which are themselves a nuisance and which are now known to be a serious factor in the transmission of certain diseases. Kitchen garbage is often mixed with miscellaneous trash and rubbish of all kinds, including tin cans partly filled with waste food materials, and sometimes with the sweepings from sick rooms which may contain disease germs. It is thus evident that the collection and disposal of the garbage and refuse of a city is a public health problem of considerable importance.

Unfortunately it is not practicable, as with sewage, to remove these wastes automatically from the houses and to transport them away from the city thru an underground system of closed pipes. The garbage and refuse accumulate at the house till called for, and then have to be hauled thru the streets to the point of final disposal, which, in some communities, still consists of low-lying dumping grounds on the outskirts of the city.

If the materials are not properly prepared at the house, or if the collection service is infrequent or irregular, the house yards may become unsightly and unsanitary. And if the collection wagons are not tight or provided with covers, liquid garbage may drip onto the streets and the lighter rubbish materials blow off onto the pavements, thus increasing the difficulties and the cost of street cleaning. The wagons themselves may smell badly, especially during warm weather, if not frequently cleaned. The final disposal

of the garbage and refuse, being at comparatively remote points, does not affect so large a proportion of the population as does their collection and transportation.

The responsibility for a satisfactory method of handling garbage and trash is thus two fold. The housekeeper is responsible for the preparation and storage of the refuse materials on the premises, and the city is responsible for providing regular collection, and for a sanitary method of final disposal.

In order to reduce the weight of the refuse and the rapidity of its decomposition, kitchen garbage, as soon as produced, should be drained of its free moisture in the sink and then wrapped in substantial waste paper and placed in a covered metal can together with other refuse. This can should be thoroly cleansed each time it is emptied. It is not necessary, except under special conditions, to provide separate cans for the kitchen garbage and for the trash. Draining and wrapping the kitchen garbage not only decreases the weight to be handled, but it prevents objectionable odors and keeps away flies. It is important to provide a sufficient number of cans to hold all the refuse that may accumulate between collections, and each can should be of such size that it may readily be handled by one man. On collection days the cans should be placed at a point on the premises where they will be readily reached, and not in the street or alley, where they can be knocked over by scavengers or stray dogs.

It might appear unnecessary to instruct housekeepers regarding the importance of these several matters, but it is a fact that in many communities very little attempt is made to care for the refuse while on the premises in a clean and sanitary manner. In Dallas, for example, a detailed examination of one of the residential sections showed that more than 85 per cent. of the houses did not have a proper covered refuse receptacle. This is partly due to the fact that the kitchens and yards are cared for by colored servants.

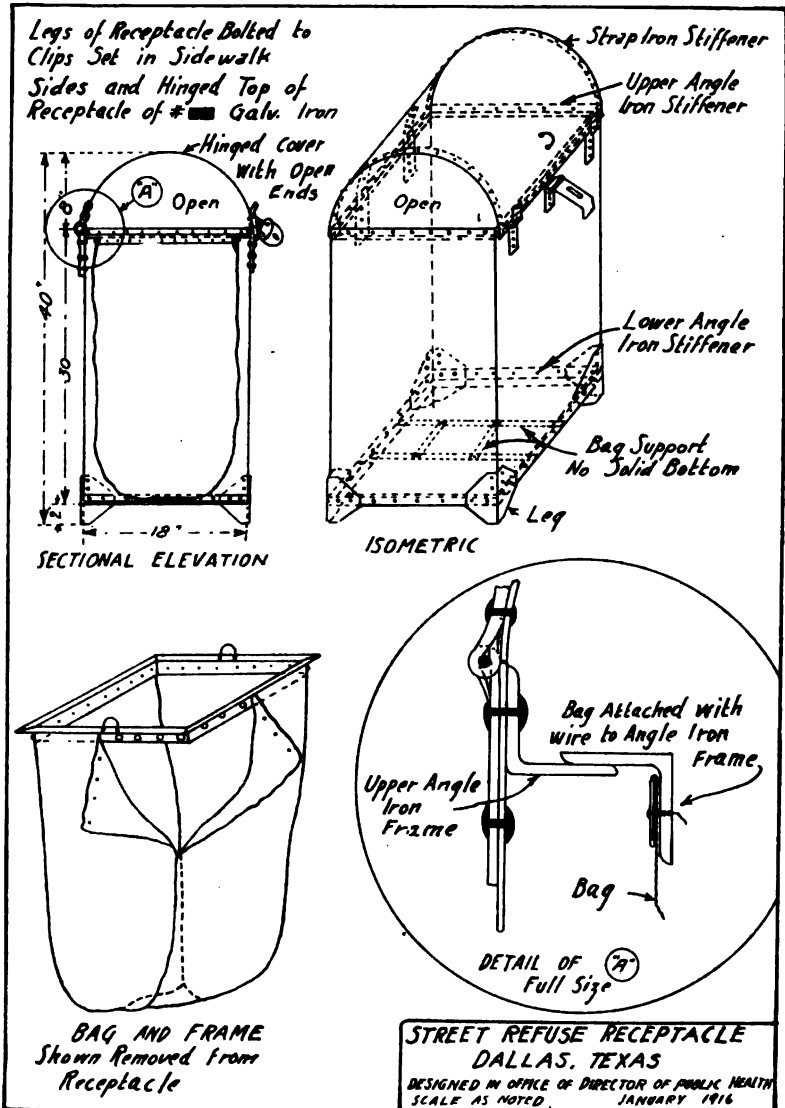
The problem of removing refuse from the individual house-receptacles to the point of final disposal is largely one of economical operation, and its proper solution requires an intimate knowledge of the physical characteristics of the particular municipality under consideration. The city of Dallas, with a population of approx-

ends. The wagons, therefore, are drawn by horses or mules, and they should be so constructed that they can turn around in a very limited space.

Other important points in the design of a refuse collection wagon, to meet these conditions, are as follows: It should be large enough so that one complete trip is made in the morning and another in the afternoon. This fills out the working day and prevents any unproductive hours. The wagon should have a permanent arched cover with several openings on each side, of sufficient size to admit the refuse. This will prevent nuisance from flies or odor, during collection as well as during transportation. The loading-edge should be as low as practicable so that time and labor need not be wasted in placing the refuse in the wagon. The wagon body should be water-tight. It should be smooth on the inside to facilitate dumping and ought to be so designed that the rear end is either hinged or removable. The openings in the top of the wagon should be so arranged that the operator can get in and stamp the refuse down solidly into the wagon body.

Since the reorganization of the Dallas Department of Public Health in May, 1915, considerable time has been devoted to developing a sanitary method of collecting and transporting the city refuse, special attention being given to the type of refuse wagon. The results of this work are embodied in the attached sketch of an improved refuse collection wagon which was recently recommended to the Board of City Commissioners for adoption. The design was made in the Department of Public Health under the immediate direction of H. W. Van Hovenberg, chief of the Division of Engineering and Administration. It is estimated that a well constructed wagon, built according to this design, will cost approximately \$300.

Another problem of interest to municipal officials is the handling of street refuse, particularly the waste papers, banana peels, etc., so often thrown onto the sidewalks or into the street gutters by pedestrians. As a possible aid to city engineers and health officers in the solution of this problem there is appended a sketch of the type of street refuse can which it is proposed to use in the business section of the city of Dallas. In lots of 25 or more this can may be furnished at a cost of about \$7.50 each.



STREET CLEANING OF SAVANNAH, GEORGIA.

METHOD EMPLOYED, COST DATA, ETC.

By E. R. Conant, Chief Engineer, Savannah, Georgia.

When an engineer becomes especially interested in any particular branch of professional work the tendency is to specialize upon the subject in question, and as a means of becoming better acquainted with this class of work immediately looks around to see what ideas and methods have been followed or are being followed by his fellow engineers. When I recently took up municipal work numerous duties were assigned to me, one of which was the problem of street cleaning, and like many other engineers I became especially interested in having Savannah a clean city, and looked around for information, ideas and assistance from those who had succeeded in this line of work.

To the novice many of the articles appearing in our magazines upon street cleaning are very interesting and at first glance appear to be of much value in determining the comparative cost of work in various localities; tho with experienced men one observes that local conditions are so varied in various municipalities that unless these local conditions are set forth in the articles describing this class of work the data contained in them are of very little value for correct deductions.

I have in mind the efforts of one of our leading municipal journals calling for data upon street cleaning; 150 cities responded with data and others with statements that records upon this class of activity had not been kept; out of the 150 reports, 38 only gave sufficient information whereby same could be used in drawing deductions as to comparative cost of work in the cities noted.

The object of this paper is not to devote much time or space to tabulation of figures, giving the great detail of cost of cleaning of an individual city, but rather to show the necessity of carefully outlining the existing conditions which bear directly upon the cost of the work, which in the writer's opinion is just as important as to give the figures themselves, and also the necessity of grouping street

cleaning data from various cities over the country, which may have generally similar local conditions. If this is done I vouchsafe that the articles which are now appearing more frequently than ever before in our magazines concerning street cleaning, garbage disposal, paving and other branches of municipal work, will be of much greater value, not only to experienced engineers, but to those young engineers, who at this time are taking up municipal work, and also to other officials of cities, who are recognizing the necessity of adopting business-like methods for carrying on municipal work.

It might be asked what is the benefit derived in going to the trouble and expense in keeping correct itemized cost of municipal work? Supposing a large department store, with its various ramifications of business carrying all classes of goods, would manage its business without keeping proper and itemized records of its purchases and sales, how would the profit and loss upon the various departments be known? Just so with the municipality, with its various branches of work, it should be known what each class of work cost. In the first place the keeping of unit cost promotes economical efficiency and assists materially in properly framing the municipal budget for the maintenance of work appropriations. Secondly, the proper and accurate keeping of itemized record of cost of departmental work, stimulates the superintendent, foremen and others in trying to obtain economical results, so as to make a favorable showing of their work, and this results in a saving of the city's money. Thirdly, the comparative unit cost of the work with other cities, when local conditions effecting the working are properly set forth, results in determining where the most efficient and economical work is being carried on, and this affords an opportunity of exchange of ideas among municipal engineers as to the methods and types of apparatus used. Fourthly, and not the least, if unit cost is kept up and an efficient organization brings about the low cost of the work, then following organizations have got to keep up with this record, or the taxpayer has an opportunity of asking why this is not done.

Coming now to the direct subject of my paper. The local conditions characteristic of Savannah should be common in the average city from 70,000 to 125,000 population, lying below the heavy frost and snow line, where the contour of the streets is such that

dry cleaning has to be resorted to. In Savannah all sewage disposal is by gravity into the Savannah river. The general elevation of the city ranges from ten to thirty feet above high water, so that the grade of the sewers must be flat, and by necessity dirt and refuse from the streets must be kept out of the sewers. Two or three of the principal down-town streets are flushed three times a week.

White labor is entirely employed in Savannah for street cleaning, but to a considerable extent the force is composed of a class which, on account of its physical condition, is unable to do an ordinary day's work; 48 per cent. employed are over 50 years of age, and 9 per cent. are over 70 years of age.

The organization of street cleaning consist of one superintendent at \$119 per month, four foreman averaging \$2.50 per day, and 70 laborers, including cart and wagon drivers, at \$1.75 per day.

METHOD OF CLEANING.

Sheet asphalt streets are cleaned daily except Sundays with scrapers, and the scrapings placed in the gutters are promptly taken up with carts; with asphalt block and vitrified brick pavement, 40 per cent. of the area is cleaned twice a week, 40 per cent. three times a week, and 20 per cent. twice a week; with granite block, 50 per cent. is cleaned twice a week, 20 per cent. three times a week and 30 per cent. once a week. Cobble-stone pavements are cleaned once in about ten days. The method of cleaning asphalt block, vitrified brick and to a large extent granite block, is by horse-driven sweepers, preceded by sprinklers, all of this being done at night. Hand brooms and scrapers are used in collecting the sweepings in piles at the gutters, and these are taken up as formed by carts and wagons during the day. Cobble-stone is hand cleaned with brooms.

The material collected from the streets amounts to approximately 20,000 cubic yards per year. A large proportion of the sweepings are delivered to a local concern, which pays the city the nominal amount of \$250 per annum for same. This party picks the coarser rubbish from the sweepings and mechanically grinds the refuse up and adds a certain percentage of cotton-seed meal and potash and sells the resulting mixture as fertilizer, which I understand is shipped to a large extent into Florida for truck farming.

COST OF CLEANING.

The accompanying tabulation prepared from accurate data gives the cost of cleaning the paved streets of the city.

Class of Pavement	Average width in Feet Total	Condition of Surface	Area in Sq. Yds.	Length in Miles	Cost of Cleaning per Year Includ- ing Removal of Debris	Cost per Mile per Year	Cost of Cleaning per 1,000 Sq. Yds. per Year	Cost of Cleaning 1,000 Sq. Yds. per Cleaning
Concrete	30	Good	22,000	1.25	\$ 480.00	\$ 322.00	\$22.00	\$0.204
Asphalt Block	35	Good	329,209	12.89	7,361.00	571.00	22.38	0.205
Vitrified Brick	38	60% Good	393,450					
Vitrified Brick	38	40% Rough	393,450	17.00	13,818.00	812.00	35.12	0.222
Granite Block	31	Fair	116,982	5.95	4,800.00	807.00	41.04	0.415
Cobble Stone	28	Rough	76,478	4.13	4,968.00	1,203.00	64.98	1.249
Sheet Asphalt	40	Good	141,319	5.04	12,226.00	2,426.00	86.52	0.277
Totals			1,079,418		\$43,650.00			

This tabulation of cost for Savannah is only another instance, as shown by other cities where correct data have been kept, where cost for street cleaning is directly proportional to the smoothness of the surface of the pavements. The tabulation shows that the cost of cleaning concrete and smooth asphalt block pavement is practically the same. The cleaning of brick is considerably higher, as the surface of worn brick pavement increases the difficulty of properly cleaning the same. The cleaning of granite block cost per equal area much more than the smoother types of pavement. Sheet asphalt being hand-cleaned makes the cost greater than if it was machine cleaned. The cost of cleaning cobble stone is five times as much as the cleaning of smooth pavements. Thus it will be seen that in adopting the type of pavement the question of cost of cleaning should be considered just as much as the cost of the material required for pavements. This matter is overlooked except by those cities which have made proper study of the situation.

An efficient timekeeper is employed, whose duty, besides keeping the time of all the employes of my department, is keeping an itemized record or cost of the various branches of the work, in such a manner that the unit cost of same is always ascertainable. The party employed is a technical graduate, who takes much interest in

his duties, and I do not hesitate in saying that the employment of this employe saves the city many times the salary paid him.

The above covers the cleaning of the city as regards the permanently paved streets, but this city, like many others, has a portion of its streets and lanes unpaved with permanent material. An expenditure of \$4,500 will be made this year in cleaning the unpaved streets and lanes and the method followed is to go thru the unpaved streets and lanes gathering newspapers, small quantities of building material and ashes thrown into the lanes, and to some extent shaping up the gutters.

The collection of loose paper in the business district of Savannah is, I believe, somewhat novel. The city, without cost to the merchants and others, places wooden boxes of one to two yards capacity at various localities in the lanes. By the way, this city has a regular system of lanes thruout perhaps 90 per cent. of its area. At this time there have been placed approximately 150 of these boxes, and the result of this has been a marked improvement as regards the cleanliness of the city. These boxes are emptied daily, and at this time the paper collected from the boxes is sold unbaled for \$3.50 per ton.

Referring briefly to garbage collection which, if not attended to properly, is to some extent responsible for an unsanitary condition of the city. Perhaps nowhere is the collection of garbage made more regularly than in Savannah. A daily collection is made over 80 per cent. of the city, that is in the populated section of the city, and elsewhere every other day, excepting on the outskirts, where collection is made two times a week. The normal amount collected averages 76 tons daily. The cost of collection and delivering to the destructor plant is \$2.16 per ton. In connection with garbage collection, it will be seen from the above that this city has not adopted motor apparatus or motor-driven sprinklers or sweepers. The writer considers this method to be somewhat in the experimental stage, but from the data furnished by the excellent paper given to the convention by Mr. Miller, the consensus of opinion is that the motor-driven sweepers are more economical than horse-driven apparatus and motor-driven sprinklers or flushers are without a question a great improvement over horse-driven apparatus. Whether it is economical to adopt motor trucks for collecting and

delivering of city refuse depends entirely upon local conditions. The writer has not thought it expedient to advocate such for Savannah up to the present time.

The cost enumerated above for cleaning Savannah's streets covers and includes all labor involved, care of live stock, maintenance of equipment, purchase of all small implements and purchase of other apparatus, sweepers, carts, etc. It also includes the cost of stock, which covers the replacement of necessary live stock. The city operates and maintains its own shop for repair work, horse shoeing, building of carts and wagons and making repairs to harness, etc., and the proper proportion of shop cost is included in the cost of work noted. Interest on investment is not included, but, if added, would not increase the cost more than 1 per cent.

PROBLEMS AND METHODS IN SNOW REMOVAL AND DISPOSAL.

*By H. S. Richards, Superintendent of Maintenance and Repair,
South Park Commissioners, Chicago, Illinois.*

One of the most exacting duties of a park official is that of maintaining walks and drives in good condition for travel at all times, even during or shortly after the severe snowstorms of winter. In a park and boulevard system like that of the South Parks in Chicago which has boulevards leading thru the crowded downtown business districts, where the traffic at certain hours is exceedingly dense, as well as thru the residence districts in which travel is rapidly increasing year by year, problems are met with that are sometimes quite difficult of solution. In this paper I will deal with those concerning snow removal and disposal as they are handled by the South Park Commisisoners, Chicago.

The operations conected with this line of work may be outlined as follows:—

1. The necessity for an immediate opening of paths thru the snow on the walks and drives and this for several reasons—

- (a) to facilitate traffic;
- (b) to prevent packing the snow which would result in an increased cost for removal;
- (c) to protect the pavements from the wear occasioned by traffic, which usually follows the ruts worn in packed snow;
- (d) to prevent the possible formation of a dangerous icy coating by alternate thawing and freezing.

2. The actual removal or disposal as soon as possible after paths have been opened, of all snow from walks and drives in the busy downtown sections by hauling to the dump or otherwise.

As to the methods of handling the snow-cleaning problems, the first means used for cleaning the walks and opening paths on the drives was that of horse-drawn plows. On all the walks, except those in front of business houses in the downtown district, who



Loaded Wagon. 11,600 lbs. or 14 cu. yds. at 830 lbs. per cu. yd.

clean the snow off their walks and deposit it in the streets, both one and two-horse plows are used—the V-shaped plow for one horse and small road graders for teams. These types have answered the purpose fairly well as they are easily handled.

Snow removal from the drives has proved a more difficult problem, as some traffic is constantly passing along packing the snow even while it is falling. The type of horse-drawn plow that has given most satisfactory service has been the four-wheeled adjustable-blade road grader. Hitches of from two to four horses, depending on the depth of snowfall and its character, as to whether it was dry and light or wet and heavy, have been used on a machine. On most of the boulevards and in the larger parks these plows are used in groups of four to six, all travelling in the same direction and lined up diagonally in such a way as to clean the entire drive in one round trip. The first plow throws the snow from the center of the drive toward the gutter, each succeeding plow cleaning its swath and throwing the ridge of snow closer to the gutter until the last plow has piled it up along the curb. In going

in one direction one-half of the driveway is cleaned and on the return trip the other half. Some of the boulevards have two drives, one on each side of a central strip of lawn. On these the snow is all cleaned towards the central parkway so as not to pile it up in front of the homes on either side of the boulevard.

In the South Park system there are at present forty-five miles of drive from which snow is cleaned in winter. To cover these drives with horse-drawn plows in a reasonable time would require a larger equipment of horses and plows than that now on hand—in fact several times as large—as the horses cannot travel faster than a walk thru the snow and altho heavy draft horses have always been used, the work with a moderate snowfall is quite wearing on them. While horse-drawn plows are covering their routes some snow is being densely compacted by the constantly passing traffic, with the result that these plows remove little more than the loose snow, being practically unable to rip the packed snow off the pavements, to which it adheres very firmly. Ruts are formed in the packed snow and traffic following these ruts wears down thru the snow to the pavement. As automobile tires in winter are usually equipped with chains the resulting wear of such traffic on the narrow strips of pavement at the bottoms of the ruts damages the pavement considerably, necessitating costly repairs in spring.

As soon as motor trucks became practical vehicles we tried various snow plow attachments on them, but have never found one that will clean snow as desired. Quite a little time and money was spent in fitting up a five-ton truck for snow cleaning work, but it did not give satisfactory service. One of the chief difficulties for a long time was the lack of traction when moving ridges of snow from the centers to the sides of the drives, even after a moderate fall of snow. As soon as the ridges acquired any depth to speak of the motor plows became helpless thru lack of traction, not that the motors were not powerful enough but because the trucks became “stalled” and slid sideways with the rear wheels revolving on the pavement.

In the winter of 1914-1915 a new type of snow-cleaning machine came to my notice. This outfit consisted of a three-wheeled gasoline tractor fitted in front with a V-shaped plow or mold-board which was removable, and a large revolving street broom mounted on

wheels to be attached behind the tractor. The construction of the outfit was quite heavy so as to withstand the strain of plowing thru banks of heavy wet snow. The plow blade has considerable curve, which causes it to travel quite close to the pavement when plowing, and on one side of the plow there is an adjustable extension or wing, which can be set at any desired angle as conditions require.

Demonstrations were given which showed the ability of the outfit to operate satisfactorily under the different conditions of snowfall usually met with, and the result was that the Park Commissioners ordered three of the outfits for service in the winter of 1915-1916. As the need for snow cleaning is felt most in the congested downtown district, which is also the most difficult district to clean, the three tractor plows were assigned principally to that district. After various preliminary trials it was learned that the broom attachments were the best for cleaning walks and for very light snow on the drives, while for the heavier snows the tractors gave better service with the plow attachments. It was finally decided that the best plan for this district was to fight the snow while it was falling and not permit it to accumulate at all nor give it any chance to become compacted by traffic.

So it was arranged that two of the tractors with brooms and the third with plow as well as revolving broom should be put into operation shortly after a snowfall began and continue operating as long as snow was falling. The third tractor was equipped with a plow in addition to a broom because it had to move the ridge of snow swept aside by the two tractors immediately preceding it. The snow was cleaned from the center to the sides of the drive, the machines travelling with the traffic at a rate up to ten miles per hour, so that they made a round trip over a particularly busy stretch of downtown boulevard a little over a mile in length every fifteen or twenty minutes. The snow is continually being brushed towards the sides of the drive ready for hauling to the dump, so that practically as soon as the snowfall ceases the machines are thru with this stretch of downtown driveway and it is in good condition.

When the machines finish work on the above mentioned drive the revolving brooms are removed, the tractors hook on the plow attachments and are then sent out to assist the horse-drawn plows in cleaning the balance of the park and boulevard drives, the tractors



Dumping Loaded Wagon. 11,600 lbs. or 14 cu. yds. at 830 lbs. per cu. yd.

being given the preference for the busy boulevards as their rate of travel is much greater than that of the horse-plows, making them less inconvenient to the travelling public. By changing shifts of drivers the tractors can be operated twenty-four hours per day; this makes them of special value for work during the night when we do not have horse-drawn plows in operation and when the traffic is not so heavy as in the daytime. Altho the road graders could also be operated all day and all night with changes of horses and drivers, that plan is not so practical on account of our inability to secure additional teams and drivers after storms, which is the time we need them the most; and the additional cost would be considerable.

These outfits have been tried out on light dry snow, heavy wet snow, sleety or icy snow and snow packed by traffic, and under these different conditions they have given first rate service. At their rate of speed of nine to ten miles per hour with sweeper attachments they are able to secure good results with revolving brooms in places where horse-drawn sweepers will not operate properly. The speed

of the latter is not sufficient to revolve the brooms fast enough to prevent the bristles becoming clogged with snow, in which condition they will not sweep the snow aside. This trouble is not experienced with the tractor brooms, as they revolve too rapidly to become clogged and consequently clean the walk or drive pretty thoroughly. With our three tractor outfits we have been able to keep a section of downtown drive one and an eighth miles long practically clean and open for traffic during a snow falling at a rate not exceeding one inch per hour. It is our intention to add to our motor snow cleaning equipment year by year so as to gradually replace the horse-drawn plows.

As to the comparative cost of work done by tractor plows and by horse-drawn plows, carefully kept records show that we have been able to do snow cleaning with tractors at a cost considerably less than that of work done by horse-drawn machines. The tractor outfits are particularly valuable in breaking up packed snow and ice, and in plowing on the drives they can throw the snow in ridges several feet deep on top of the curb, leaving the gutters entirely free and open, which is a most desirable feature. Horse-drawn machines are able to plow only a part of the snow up over the curb, leaving most of it in the gutters.

No matter how well a working force may be organized, it seems that at times, as in emergencies for instance, previously made plans will not work out to perfection. Sometimes we get caught by sleet storms, which cover the drives with frozen slush and ice, leaving them in a bad and dangerous condition. After one such storm last winter considerable slush was frozen on one section of drive-way which we had been unable to finish cleaning before it froze. The next day the ice was picked loose and hauled to the dump. When using laborers it was found that it required four men with picks to loosen enough to keep a team busy hauling it away. We soon learned that a tractor pulling a road grader worked very well on the frozen slush and ice and with this combination enough was loosened in one hour to keep seven teams busy four hours.

In addition to plowing or sweeping, the tractors with plow and broom attachments removed have been repeatedly used to good advantage in hauling wagons loaded with snow from the downtown district to the dump. For one of the tractors an especially large

wagon holding fourteen cubic yards, water measure, was built and the tractor had no trouble handling it. A special device fitted to this wagon enabled the tractor to dump out the fourteen yards of snow in a few seconds.

I have for some time thought of disposing of the snow on the downtown boulevards thru the sewers so as to eliminate the expense of taking it to the dump, so last winter a device consisting of a water turbine armed with three free blades and mounted in a wire cage or basket of a size to permit it to be set in a sewer man-hole was made and tried out. The water turbine was connected with a fire hydrant, the stream of water revolving the turbine and then flowing thru the wire basket into the sewer. The free blades on the turbine agitated the snow shoveled into the basket and mixed it with the water which carried it on thru the sewer. With a pressure of fifteen to twenty-five pounds the machine disposed of all the snow that two men could shovel into the wire basket, and with a higher pressure it should take care of all that four men can shovel into it.

Granulated rock salt sprinkled over the drives has also been used for removing snow. There have been some complaints, however, against its use on the park and boulevard drives, the chief objections being that it has a tendency to melt the snow and form puddles of water which is splashed upon automobile bodies, where it forms white spots when dry, due to the salt dissolved in the water; also, that it is tracked into stores and houses, soiling floors and carpets. For this reason we have had to use it sparingly, and then usually to "rot" or weaken the icy coatings formed after sleet storms or on densely compacted snow and ice, so that snow-plows or graders would be able to rip such coatings loose from the pavements. Immediately after sleet storms walks and drives are made safe for travel until the snow cleaning machinery can remove the ice, by spreading torpedo sand lightly over them from specially designed wagons and carts.

The problems connected with snow removal and disposal are becoming of more and more importance every year and merit considerable attention, but it will undoubtedly be some years before machinery and methods are perfected which will enable us to meet all the requirements in a practical, efficient and economical manner.

Until then every contribution towards the solution of these problems will be heartily welcomed by those who realize the importance of snow cleaning work in our large cities.

DISCUSSION.

MR. LA BERGE (In response to request by the President) :
Mr. Chairman, I am sorry indeed that I have no data as to snow removal. Altho I belong to the city of Montreal, I do not belong to the staff of the city and have not occasion to know exactly what snow removal costs the city. I do know that, as I have seen for three or four years, they use the sewers extensively in which to dump the snow collected on the streets. At first we thought it was an impossibility, but it has worked very satisfactorily. It has diminished the cost of snow removal by a very good sum. I am very thankful that you asked me to speak on the matter, but I have no data nor statistics.

FLUSHING—ITS PLACE IN THE STREET CLEANING FIELD.

By Raymond W. Partin, Engineer with the New York Bureau of Municipal Research.

This paper has three objects in view—

1. To point out, as far as possible with the limited data at present available, the advantages and limitations of pavement washing as a method of street cleaning;
2. To suggest a basis for making further comparisons between the results secured from various types of equipment;
3. To present the experience gained in a few cities for the benefit of others, with the hope that others will reciprocate.

STREET CLEANING IN GENERAL.

The various methods of cleaning streets which have been so far developed or which are in the process of development may be classified as—

1. Street sweeping;
2. Street washing;
3. Vacuum cleaning.

Of these three general methods, the latter has just begun to emerge in a somewhat imperfect form from the experimental stage. Altho vacuum machines are on the market, their value has not as yet been definitely established and this method cannot be considered as being practically available for general adoption.

Fine Dust Problem Forces Changes in Methods.

The extensive use of the automobile has accompanied the great extension of the area of hard surfaced pavements and the increasing demands on the part of the public for clean streets. This high-speed traffic on smooth street surfaces has made the fine-dust

nuisance much worse and more noticeable to the people. The various methods of sweeping, both by hand and by machine, have, even with the most improved types of sweeping equipment, failed to solve effectively the fine-dust problem. Changes in method have been forced upon the officials.

So definite are the needs of the cities for results better than those produced by sweeping, that it may be safely prophesied that sweeping in the future will cease to be the primary method of cleaning a modern city and will become an auxiliary to other more efficient methods or used where only rough cleaning is desired.

Sprinkling an Expensive Nuisance.

To reduce the dust nuisance most communities have, prior to the development of satisfactory flushing equipment, systematically sprinkled the street surfaces in the business and many of the residential sections. Sprinkling temporarily sticks fine dust to the pavement. On hot days the effect of this work is so soon lost that numerous repetitions are necessary to prevent the recurrence of dusty conditions. Careless driving of sprinkling carts and poor judgment in the use of water have been common causes of muddy streets or the splashing of pedestrians. Accidents due to the skidding of vehicles on the greasy surface of a wet and dirty street have also occurred.

In general, sprinkling has been considered a necessary evil, but now it can better be termed, in all but a few cases, an expensive and unnecessary nuisance that should be eliminated by the substitution of a method of cleaning which removes the cause for sprinkling.

Washing vs. Vacuum Cleaning.

The vacuum cleaner presents great possibilities in the removal of fine dust without the use of water. Equipment has been already developed which will effectively clean smooth pavements which are in good repair. On rough block streets or wherever depressions exist, these machines leave much to be desired. Assuming that entirely satisfactory equipment of the vacuum type is perfected for dry cleaning, and it is believed that such equipment will be developed in the near future, it is questionable whether this type of ma-



1. Horse-Drawn Squeegee At Work. The stroke or mud wave is clearly shown moving toward the gutter at the right.

chine will ever be able to remove effectively mud or wet dust. At present it is obvious that the only practical method available for combating the fine dust and mud nuisance is some form of pavement washing.

The methods of pavement washing are divided into two main groups:

1. Pavement scrubbing;
2. Pavement flushing.

Scrubbing Method Limited to Smooth Pavements.

Pavement scrubbing is almost entirely limited to the use of machine squeegees, altho in Europe hand squeegees are used to some extent.

Machine squeegees may be either horse-drawn or automobile-driven. This type of equipment consists of a heavy roller equipped with rubber fins usually attached behind or under a water tank. The roller is rotated against the pavement after the street is heavily sprinkled with water from its own tank or from other equipment. It scrubs the surface thoroly wherever it touches, driving the mud wave or stroke toward the gutter. There the heavy ma-

terial settles, the water drains off, and it is possible to pick up the dirt from the surface of the street. (See photos Nos. 1 and 2.)

This equipment, by its very nature, is practically limited to smooth pavement in good repair, such as asphalt, asphalt block, wood block and perhaps concrete. On such streets it produces very effective results with a limited use of water.

Motorized squeegee equipment, tho in use for a number of years in Europe, has only recently made its appearance in this country.

FLUSHING DEVELOPMENT.

The general adoption of flushing in the last few years is marked. This has been largely due to the introduction of new types of equipment, especially those mounted upon automobile trucks.

Flushing is naturally divided into two classes:

1. Hand flushing equipment;
2. Mechanical flushing equipment.

Probably the first flushing of streets in this country was performed at irregular intervals upon restricted areas by the use of the ordinary garden or fire hose. The development of special hand-flushing equipment has, however, mainly taken place contemporaneously with that of mechanical-flushing equipment.

Hand-Flushing Equipment.

Hand-flushing equipment may be divided into two classes:

1. Ordinary hose with nozzle and carrier or reel;
2. Special pipe lines and other elaborate equipment.

The latter class may best be illustrated by the Buffalo "Portable Pipe Lines," which are characteristic of many of the special developments which have been used both in this country and abroad. (See Photos Nos. 3, 4, 5 and 6.) This class of equipment, as far as can be learned, has the disadvantages of being awkward to handle (very often requiring the use of more than two men and one or more horses), obstructing streets, and resulting in higher costs than is the case with the best types of hose equipment.



2. Automobile Squeegee. A recent development in this country which should be successful.

A superior type of hose equipment is represented by the type recently developed for use in New York City. This development is given in some detail, as it represents an improvement which may be of use even to the smallest city.

Recent Improvements in Hand Flushing.

Early in 1914, Commissioner John T. Fetherston, of the New York Department of Street Cleaning, found it necessary to improve both the equipment and the procedure used in hand flushing. The commissioner formed a committee among his officers to report on the flushing as then done and to suggest changes. Very few concrete suggestions were secured and it was thought best to make a further investigation. At the commissioner's request, the Department of Water Supply, Gas and Electricity, which has charge of the water system, and the New York Bureau of Municipal Research, an organization independent of the city government, both lent their co-operation; the former with the view to finding some way of reducing what it considered an unnecessary waste of water, and the latter as a part of a program of co-operation with a view to assisting the commissioner to discover and instal standard procedure in the department.

Hand flushing was considered at this time to be one of the most important subjects needing study—for several reasons:

1. It constituted, in the minds of the department officers, the only satisfactory means which was immediately available for combatting the fine-dust and mud nuisance;
2. No money for special equipment of a more expensive nature could be secured and the commissioner wished to do better cleaning;
3. Complaints regarding the methods of performing this work were numerous, especially from the officers of the water department, who felt that great quantities of water were being unnecessarily wasted and who threatened to forbid the continuance of the work;
4. It was believed that by the development of some simple new equipment and better procedure, greater economies, both in water and in labor, could be secured;
5. It was believed that the use of hand-flushing methods would be especially effective in securing a quick clean-up after snow storms, when mechanical equipment would not be satisfactory;
6. It was not certain that mechanical flushing would really be as cheap as hand flushing under New York City conditions.

New York Formerly Used 2½-Inch Hose.

Up to the time of the study, the Department of Street Cleaning had been using ordinary 2½-inch fire hose and 1¼-inch nozzles. The equipment was carried on the regular sweeper's can carrier or dragged over the pavement from place to place by sweepers. That this equipment was not only ill adapted to the work, but heavy, unsightly and liable to cause rapid deterioration of the hose on account of the sharp bends which were necessary, can easily be imagined after observing Photo No. 7, which shows a sample of this old equipment. Investigation at that time indicated that:

1. An average of 1,800 gallons of water was being used per thousand square yards of pavement cleaned;
2. Other cities were using smaller sizes of hose and nozzles with apparent satisfaction;
3. 1½-inch and 2-inch hose and small nozzles would do the work of cleaning properly.



3. Buffalo "Portable Pipe Line," Showing Nozzle on 20-Foot Arm Obstructing Half of Street.
4. Buffalo "Portable Pipe Line," Showing Swivel, Nozzle and Nozzle-Arm Details.
5. Showing Short Hose Connections Between Pipes, Wheels, and Nozzle-Arm Connections.
6. One Team Serves Two Gangs Using "Portable Pipe Line" Equipment.

Experiments Lead to Adoption of Two-Inch Hose.

Objection was raised by street-cleaning officers to the recommendation that hose as small as 1½-inch be used.

Two points of view developed, one looking primarily at the waste of water and the other at the waste of time. It became necessary to run a second set of experiments to determine the size of equipment which would be cheapest to operate from the taxpayers' or general city viewpoint, taking into account both the cost of labor and the cost of water.

This second set of experiments, conducted alternately upon 1½-inch and 2-inch equipment, resulted in the selection of the 2-inch equipment as standard for the city. Attention was at the same time called to the possibility of using the smaller size with equally good results wherever the pressures at the hydrants were in excess of 50 pounds per square inch.

General Principles Established.

As a result of these and further experiments, the following general principles appear to be established:

1. That the economical size of equipment is dependent upon the hydrant pressures available and the length of hose used;
2. That when the pressure at the nozzle is in excess of 25 pounds per square inch, water is delivered thru a ¾-inch or 1-inch nozzle faster than it can be properly used by two men and that is accompanied by excessive splashing;
3. That when the pressure at the nozzle is less than 18 pounds per square inch, water is not delivered fast enough to keep up with the men nor with force enough to enable them to do effective work;
4. That the smallest size hose which will give pressure at the nozzle between 18 and 25 pounds is the most economical for use;
5. That better results can be secured by spraying ahead as far as the stream will reach, to give the material on the street a preliminary soaking prior to the direct flushing, than can be secured by the direct flushing of a dry pavement;

6. That larger quantities of water are required to clean rough pavement than smooth, and therefore a slightly larger nozzle may be used to advantage. (It is estimated that a $\frac{3}{4}$ -inch will be satisfactory for asphalt and a 1-inch for rough Belgian block) ;

7. That shut-off nozzles are necessary whenever working in traffic, both to save water and to prevent accidents ;

8. That where water mains are large enough for proper domestic and fire supply, flushing will not interfere with the ordinary household use ;

9. That a hose reel will enable the gangs to do more work with the same expenditure of energy and at the same time lengthen the life of the hose ;

Equipment and Procedure Improved.

As a result of the studies and conclusions reached, a new hose reel, new hydrant equipment, and improved procedure were adopted by the department and put into effect. (See Photos Nos. 8 to 13.)

The procedure in handling the equipment may be described as starting with the hose reeled so that the nozzle is on top or outside; commencing to unreel when at a distance equal to the length of the hose from the hydrant; unreeling toward the hydrant; placing the reel on the sidewalk near the hydrant; flushing from the point nearest the nozzle past the hydrant and as far as the hose will reach beyond the hydrant; and reeling from the hydrant toward the nozzle; thus completing the area served by a single hydrant. Whenever moving the hose, the "hydrant man" is required to pick it up in loops and drag it ahead in such a way that it will not cross other loops. He is expected to keep a loop at the nozzle end, even with or slightly ahead of the "nozzle man," so that the latter will be free to move without assistance at all times.

Results of New York Studies.

The results of the studies can best be indicated by the illustrations numbered 8 to 13, which show the improved reducer which can be put on the hydrant without the use of a wrench; the improved reel, with its tool box, third wheel and special arrangement for receiving the reducer in winding on the reel; the method of placing the hose

along the curb or in the gutter out of the way of traffic; the method of direct flushing; the method of moving the hose from place to place during flushing; the advantage of the shut-off nozzle, and the method of reeling.

The first cost of the equipment is approximately as follows:

Three 50-foot lengths 2-inch rubber hose, at 60c per foot....	\$ 90.00
One ¾-inch shut-off nozzle.....	7.00
One 2½-inch to 2-inch reducer, hand swivel type.....	2.25
One hydrant key .....	.15
One hose reel	30.00

Total\$129.40

(Rubber-covered hose is preferable to cotton jacket hose for this work.)

Upon the uniform basis of calculating unit costs described hereafter, the results secured by the use of the "Buffalo portable pipe line" are compared with the most conservative result secured in the use of the New York equipment on the following table:

COMPARATIVE ANNUAL AND UNIT COSTS—200 DAY SEASON—ONE EIGHT-HOUR SHIFT PER DAY.

BUFFALO PORTABLE PIPE LINE.		NEW YORK EQUIPMENT	
<i>Conditions—</i>		<i>Conditions—</i>	
Dirty rough, stone work—Day work.		Dirty Belgian block—Night work.	
Force—gangs.		Force—1 gang.	
First cost of equipment—\$200.		First cost equipment—\$130. (Hose, \$90.)	
Estimated life—2,000 working days.		Life hose—250 working days; other equipment, 1,200 working days.	
Interest at 5 per cent. Water at 5c per 1,000 gallons.		Interest, 5 per cent. Water at 5c per 1,000 gallons.	
Area flushed by 4 gangs per shift—30,300 sq. yds.		Area flushed per shift—23,000 sq. yds.	
Area flushed by 4 gangs per year—6,060,000 sq. yds.		Area flushed per year—4,600,000 sq. yds.	
<i>Fixed Charges—</i>		<i>Fixed Charges—</i>	
Depreciation reserve.....\$ 10.00		Depreciation Reserve (hose not included)....\$ 7.00	
Interest	10.00	Interest	6.50
<i>Maintenance—</i>		<i>Maintenance—</i>	
Repairs and painting..... 25.00		Repairs and painting..... 15.00	
Storage	40.00	Storage	20.00
<i>Operation—</i>		<i>Operation—</i>	
Laborers—4 at \$2..... 1,600.00		Hose	72.00
Assistant foremen—4 at \$2.50	2,000.00	Laborers—2 at \$2.....	800.00
Teams—2 at \$5..... 2,000.00			
Water at 2,700 gallons per 1,000 sq. yds.....	818.00	Water at 900 gallons per 1,000 sq. yds.....	207.00
Total annual cost....\$6,503.00		Total annual cost....\$7,127.50	
Cost per 1,000 sq. yds.—\$1.07.		Cost per 1,000 sq. yds.—24.5 cents.	



7. Makeshift Equipment in Common Use in New York City Before 1915.

When cleaning 30,000 sq. yds. per day, cost per 1,000 sq. yds. is 19.8 cents.

Upon less heavy work and smooth pavements, New York gangs have been able to flush effectively 30,000 or more square yards in eight hours, making as many as 45 connections to hydrants. This means unit costs per 1,000 sq. yds. of 19.8 cents or less.

There seems no reason why any city cannot secure the same results with similar equipment if it so desires, provided hydrants are not over 400 feet apart.

Mechanical Flushing Equipment.

The various types of mechanical flushing equipment which have so far been produced may be listed approximately in the order of their development, as follows:

1. Ordinary sprinkling wagons, operating with their valves wide open;
2. Horse-drawn flushers utilizing air pressure (see Photo No. 14);
3. Horse-drawn flushers, equipped with gasoline-driven pumps (see Photo No. 15);
4. Automobile flushers (see Photos Nos. 16, 17, 18) with either plunger or centrifugal pumps driven directly from the automobile

engine, separately driven, or driven by means of an electric motor which secures its power from the engine, or in case of an electric automobile, directly from the storage battery;

5. Trailer machines which may be attached to an automobile tractor (see Photo No. 19) ;

6. Equipment for street railway work the development of which has been as follows :

- a. Ordinary street railway sprinklers with valves wide open ;
- b. Special flushing cars with rigidly attached nozzles supplied with pressure by a pump (see Photo No. 20) ;
- c. Special flushing cars with a flushing nozzle attached to a swinging arm which enables the car to clean a wide street (see Photo No. 21) ;

7. Combination equipment, such as a flusher and squeegee mounted either on an auto truck or tractor and trailer (see Photo No. 22).

Effect of Minor Differences in Type Not Investigated.

A separately driven pump mounted at the rear of a machine may require the use of an extra man to operate the machine as compared with equipment on which the pump is driven directly by the automobile engine. Increased cost will undoubtedly also result from the increased use of gasoline in driving two engines.

The size of the tank carried determines the distance which the machine can travel per filling. This means that larger tanks, by saving time in loading, will enable the equipment to cover more area per shift. At the same time, the size and weight of the equipment and the operating expenses are increased. Just what the economic limit in tank size is has not as yet been determined, but 1,200 and 1,500-gallon tanks are at present most commonly used on automobile equipment and 750-gallon tanks appeared to represent the maximum size for horse-drawn equipment. The limits of size for tanks on trailers and street-railway cars are considerably higher.

The laws governing the number and location of nozzles, as well



8. Improved Reel in Place on Sidewalk Near Hydrant, Preparatory to Flushing. Note reducer, which can be easily attached to hydrant without aid of wrench.
9. Sprinkling Ahead to Soak Material on Pavement Preparatory to Flushing. Note hose laid close to curb where it will not interfere with free flow of water to gutter.
10. Direct Flushing. "Hydrant man" carrying first loop of hose to relieve "nozzle man" of the load.

as their design, have not been clearly worked out. On the theory that the wave of water and dirt caused by the first nozzle should be given time to move to a point where the water from a second nozzle will be effective upon the same dirt, it would appear that those machines equipped with four nozzles, two crossed in front and two located in the rear, are meeting the conditions best. With this arrangement, the water from the left-hand front nozzle will

move the dirt across the path of the machine to a point where the stream from the right-hand rear nozzle is effective before that stream has been brought into action by the forward movement of the equipment. On the other hand, the theory is advanced that a heavy flush of water from one point is more effective than the same quantity of water applied from two points. This theory has been put into practice by the Moreland Truck Company in the patented flushing head which they have developed. (See Photograph 18.)

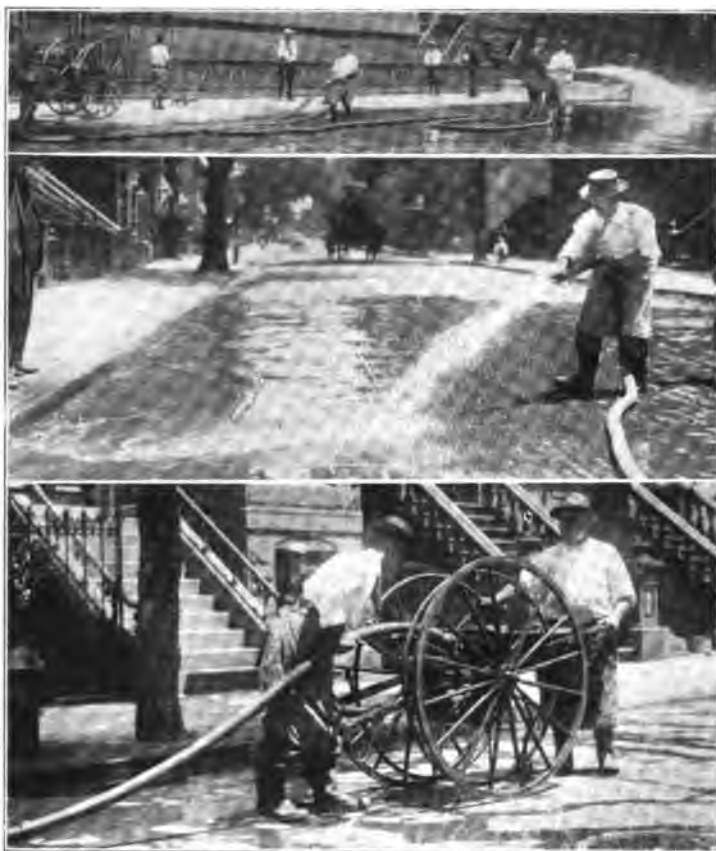
With hand-flushing equipment, observation indicates that men will remain on the job until what is practically a standard quality of cleaning has been secured, regardless of the type of equipment which they may be using. Therefore, the effect of type in hand flushing is well indicated by the comparison of costs. Such a comparison has already been given for the "Buffalo portable pine line" and the New York City equipment.

The innumerable minor differences in the design of equipment and the inability to secure sufficient dependable data to indicate the effect of these differences in design, made it impractical to attempt to show more than the effect of the major differences in type in this paper. These major differences in type may be classified as hose-flushing equipment, horse-drawn flushing equipment, automobile-flushing equipment and street-car flushers.

BASIS FOR COMPARING RESULTS.

Each type of equipment has its own characteristics. Assuming that several types are physically adaptable to local conditions, the problem which confronts public officials is that of choosing the particular type and method of using equipment which will most efficiently and economically perform the work under local conditions. This generally boils down to the question of what type of equipment will do satisfactory work at the least cost.

In attempting to answer this question, the writer has been surprised at the difficulty in securing adequate data from which dependable conclusions could be drawn. This is due to several reasons, among which are the limited experience with many of the recently developed types of equipment, the constant improvements which are being made in equipment, the absence of standard meth-



11. Moving the Hose Ahead Systematically. Note the position of the loop near "nozzle man" to allow his free movement, while the "hydrant man" moves the remainder of the hose ahead.
12. Shut-off Nozzle Prevents Excessive Splashing when Working Close to Curb, Saves Water, and Prevents Accidents.
13. Reeling. The third wheel supports the reel. Portion of reel drum is cut away to receive hydrant connection.

ods of gathering or expressing data, and very often the absence of cost records of any kind.

Elements Affecting Costs.

The more important elements which affect flushing costs are given below:

1. The quality of work required;

2. The condition of the pavement;
3. The length of the working season in days and shifts per day;
4. The rates of pay for employes and teams;
5. The cost of supplies and water;
6. The type of equipment.

Standards of Quality Needed.

Standards of measurement have not yet been developed for the work of street cleaning. It is evident that a measure must indicate the relation between the quantity of dirt remaining on a given area of street after cleaning to the quantity present on the same area prior to cleaning. It is also evident that until it is possible to measure the quality of work, the comparative results can only be expressed upon an arbitrary basis or measured by personal judgment. An interesting step in the direction of a generally applicable standard of measurement has recently been made by the efficiency department of the city of Los Angeles, Cal. This is as follows:

On each route a section of street was selected for use in determining the percentage of dust removed by flushing. The section selected was 50 feet long and free from visible litter. Its width was the width of the street (or that part of the street which was flushed) less a gutter strip at each curb. The gutter strips were excluded from the test area because of the deposits that might occur in them from the flushing of other sections of the street, and because usually they would not be dry in time for a proper completion of the test. The test area was divided into five equal sections, each 10 feet wide. Assume them as numbered consecutively, 1 to 5. Sections 1 and 5 were cleaned very carefully before flushing, as late in the evening as was possible, to avoid interference from traffic and to approximate as closely as possible the street condition at the time of flushing. Soft, fine-haired push brooms were used. The sweeping was carefully and thoroly done and the cleanings were collected and so marked as to identify the section of their origin.

Early the following morning, after the street had been flushed and had dried out, and before the regular hand-sweeper and the full flow of traffic had come on, Section 3 was cleaned in the same manner. Sections 2 and 4 were not used except to provide areas



14. Horse-Drawn Air Pressure Flusher. Pressure obtained by filling a closed tank from hydrants, thus compressing the confined air.
15. Horse-Drawn Flusher with Gasoline-Driven Pump on Rear End. Uniform pressure provided at the nozzles.

contiguous to Section 3 which would correspond to the rest of the street.

The materials collected were carefully weighed and screened. The average of the collections from Sections 1 and 5 was used as closely approximating the weight and composition of dirt on Section 3 before flushing. The weight and composition of dirt on Section 3 after flushing was obtained by direct experiment as explained above.

The quality of cleaning by the flushing method is very largely dependent upon the number of trips which a machine makes over a given area, or the amount of time which is spent on this area. In some cities it is the practice on dry days to give the pavement a preliminary sprinkling before flushing with the view to loosening

the dirt from the street surface. Other cities, in cleaning streets 30 to 40 feet wide, flush the whole street in a single trip. Perhaps the most general practice on streets of this width is to complete the flushing in 4 trips thru the street, which means that a strip 8 to 10 feet wide is cleaned each trip.

In this paper it is assumed that the quality of mechanical flushing is measured by the number of trips thru a street of a given width. It is also assumed that 4 trips thru streets 30 to 40 feet wide will give results comparable in quality to those produced by hand flushing or squeegeeing.

Defective Pavements Increase Cost of Cleaning.

Poorly designed pavements or those in poor repair will increase the cost of flushing in two ways: First, by forcing the equipment to spend more time in cleaning a given area or to travel more times over the ground to secure a thoro cleaning, and second, by increasing the cost of repairs and reducing the life of the equipment by exposing it to unreasonably hard usage.

In the estimates of cost which follow, a series of uniform assumptions has been made in estimating the life of automobile and street-car equipment. These assumptions, noted at the top of the various tables, are made dependent upon the distance which the machines travel, and a maximum limit is placed upon the life of the equipment to provide for obsolescence.

Length of Season and Number of Shifts.

In northern cities winter limits the flushing season, while cities like Los Angeles can flush 365 days per year.

The working time of the equipment is further limited by the number of shifts worked per day and the number of days worked per week. The ordinary limits may be stated as follows:

Weeks in Season	Days wkd. pr. wk. Length of Season	Working Time in Shifts Per Day							
		Northern Cities				Southern Cities			
		One Shift Per Day		Two Shifts Per Day		One Shift Per Day		Two Shifts Per Day	
		6	7	6	7	6	7	6	7
30	Apr. 1-Nov. 1	183	214	366	428	...	...	...	...
32	Apr. 1-Nov. 15	196	289	392	458	...	...	...	...
52	Jan. 1-Dec. 31	...	...	...	...	313	365	626	730



16. Automobile Flushing Machine. Note the fixed nozzles and sprinkler heads.
17. Automobile Flushing Machine At Work. This illustrates the most common method of operating this type of machine.

In making comparisons of costs it is clear that the interest on investment and many other expenses do not increase in proportion to the length of the working season. In the comparative estimates of cost hereafter shown, four assumptions have been used, as follows:

1. Two-hundred-day season—one shift per day;
2. Two-hundred-day season—two shifts per day;
3. Three-hundred-day season—one shift per day;
4. Three-hundred-day season—two shifts per day.

The resulting effect of variations in length of season is made apparent by the unit costs shown in Plates II and IV, as compared with those shown in Plates III and V, where the average unit costs for flushings have been reduced by working two shifts, as compared with working one shift—

from 15.9 cents to 13.9 cents

from 14.6 cents to 13.2 cents

from 26.7 cents to 24.3 cents

from 15.0 cents to 11.2 cents

from 13.6 cents to 11.6 cents

from 25.6 cents to 23.5 cents

Such economies are largely possible on account of the more continuous use of high-priced equipment.

Basis for Comparative Cost.

In order to reduce the results secured by different types of equipment to a comparative basis, the elements of cost have been grouped as shown below. The three elements—rates of pay to employes and teams, cost of supplies and water, and the type of equipment, which have not already been discussed, are included in the description which accompanies this grouping.

A series of comparative estimates has been prepared (see Plates Nos. II to V). These plates show comparative annual and unit costs for cleaning with various types of equipment. They are based upon actual experience secured in various cities (see Plate I), which has been translated into common terms. In all of these estimates it is assumed that the cost of flushing or squeegeeing ends when the dirt has been washed or pushed into the gutter where it can be picked up and removed by the regular street patrol sweepers or gang.

The costs are expressed as follows:



18. Automobile Flusher in Los Angeles. Note the special flushing head carrying five nozzles.

First Cost

Fixed Charges

Interest

Depreciation Reserve

Maintenance Charges

Garage or Storage

Repairs and Painting

Operating Charges

Horse Hire or Expense

Personal Service

Supplies and Material

Water

Etc.

Each of these items has been as far as possible reduced to a uniform basis as follows:

Interest is figured at 5 per cent. on the cost of the equipment.

The Depreciation Reserve is figured as equal annual installments sufficient to pay off the first cost of the equipment in a period equal to the estimated assured life of the equipment, or, in other

words, the average amount which is necessary to set aside each year in order that the capital investment may be maintained intact.

The combination of the interest and depreciation charges corresponds to the assumption that the public has invested a certain amount of capital, on which they are entitled to receive from those paying for the work a return equal to that which might be secured thru another investment and at the same time a guarantee that the capital shall not be lost.

Garage or storage charges are assumed to include the usual care of equipment, such as washing and housing. A constant figure is used for all similar equipment.

Repairs and painting have been determined as closely as possible from actual experience and like figures are used for similar equipment.

Horse-hire or expense has been reduced to a standard figure of \$1.50 per horse per working day as being a fair cost for city-owned horses.

Personal service has in each case been figured on the basis of 8 hours work per day and employment of all but unskilled labor is assumed to be on a "rain or shine" basis. Uniform rates have been assumed for similar service. These assumptions are liberal, but being the same in all cases, give comparable results.

Supplies and materials have been figured upon uniform unit prices in each case, so that the only effect on costs will be that of the quantity used. The economy of the equipment itself is thus made evident.

Water has been taken into account in all estimates at a fixed price of 5 cents per 1,000 gallons. The minimum rate made to large private commercial users may, in any locality, be used as the unit cost for water used in cleaning streets if no better figure is available.

The Fields of Flushing Equipment.

The most economical examples of the various types of equipment are shown by the cost comparisons to be—



19. Tractor Trailer Flushing Equipment. This is a new type built for Springfield, Mass. Note the pump mounted on the tractor and 2,000-gallon tank mounted on the trailer.

1. New York, hose equipment;
2. Milwaukee, horse-drawn equipment;
3. Chicago, auto equipment;
4. Worcester, street-railway equipment.

To determine the relation of these various types of equipment to each other, a diagram was drawn (see Plate VII), which shows the unit cost of cleaning various areas with the four types of equipment. The data used in constructing the diagram were based upon those given in Plates II to V and the assumption that the area represented the schedule area to be covered each day for 200 days.

Study of this diagram revealed the fact that hose flushing on small areas was the most economical method; that up to 40,000 sq. yds., the horse-drawn equipment was next in economy; that from 40,000 sq. yds. to 90,000 sq. yds., the hose was about as economical as the automobile; that from 90,000 sq. yds. to 120,000 sq. yds., the automobile was supreme, and for daily schedule areas of over 120,000 sq. yds., the automobile and street-car equipment give nearly the same economy.

This means that small cities which do not have over 40,000 sq. yds. of hard pavement to clean each day can better afford to use hose equipment if hydrants are close enough together and plenty of water is available. If local conditions prevent the use of hose, then horse-drawn equipment is economical if only flushing is required. If both flushing on the hard pavements and sprinkling on the macadam or gravel streets is desired, the automobile appears to be by far the most economical equipment.



20. Street Railway Car Flusher. Developed in Cleveland, Ohio. Notice the centrifugal pump on front platform and nozzle attached rigidly to car.

In large cities there appears to be no doubt that the automobile and street-car equipment are the most economical, with the possible exception of those small or inaccessible areas which the larger equipment cannot reach. On such areas hose equipment can well be used as auxiliary to the machines.

Wherever the city has areas of more than 120,000 sq. yds. on street-railway streets, the street-car equipment should be economical. Wherever the street-car franchise provides for the sprinkling of the right of way, the adoption of this type of equipment is especially to be desired, first, to eliminate sprinkling, and second, to replace it by flushing, which is greatly to be preferred. *Wherever such franchises exist it should be possible for the municipality and the street railway company to enter into an arrangement which will be of benefit to both.* The costs of street cleaning should be reduced and, if really effective sprinkling of the railway area has been provided, the expense to the traction company should be reduced as well.

Flushing vs. Squeegeeing.

The field of the squeegee is limited to smooth pavement in good repair, as has been previously stated. To show how such work compares in cost with flushing, the table shown on Plate VI was made. A portion of the data on which these estimates are based is given in

the two tables which follow. These seem to indicate that large areas of smooth pavement can be almost as economically cleaned by squeegeeing as by flushing. The automobile equipment has not yet been in use long enough to prove its worth. There is every indication that it will be both efficient and economical, as the estimate of cost based on recent tests shows.

SQUEEGEE PRACTICE, EQUIPMENT AND RESULTS. HORSE-DRAWN SQUEEGEES.

Source of Data	Milwaukee, Wis.	Washington, D. C.
Make of equipment.....	Kindling	Kindling and Hvass
Water tank capacity—gallons..	500	500
Length of squeegee roller.....	7 feet	7 feet
Machines worked in battery....	1 to 3	4 and 1 sprinkler
Average area cleaned per shift per machine	35,000 sq. yds.	62,500 sq. yds.
Water used per 1,000 sq. yds..	400 gallons	140 gallons
First cost squeegee.....	\$1,250	\$1,250
First cost sprinkler.....	.....	\$265
Rate of pay—foremen.....	.....	\$900 per year
Rate of pay—drivers.....	.....	\$2.00 per day
Rate of pay—laborers.....	.....	.....
Cost of horses per working day, less fixed charges.....	.....	90c each
Cost of horses hired, per day..	Driver and team \$5.00	.....
Cost of repairs and painting for year per machine.....	.....	\$158.50
Cost of repairs and painting for year per sprinkler.....	.....	\$58.20
Renewal of rollers.....	Est. 1 per year	Est. 1 per year
Cost of water per 1,000 gallons.	6 cents	.....

SQUEEGEE PRACTICE, EQUIPMENT AND RESULTS. AUTOMOBILE EQUIPMENT.

Source of Data	Test in Dallas, Texas, and Estimates of Manufacturers' Agent.
Make of equipment.....	Sterling-Kindling
Rated truck size.....	3½ ton
Motive power—amount	Automobile engine
Source of squeegee driving power.....	8 feet
Length of squeegee roller.....	900
Water tank capacity—gallons.....	1
Machines worked in battery.....	125,000 sq. yds. to 197,000 sq. yds.
Area cleaned per shift per machine.....	211 gallons
Water used per 1,000 sq. yds.....	Gasoline—0.2 gallon
Fuel used per mile.....	7 miles per hour
Speed of machine (Est.).....	\$6.100
First cost machine.....	5c per mile
Tire cost (Est.).....	\$315.00 per year
Maintenance and repairs (Est.).....	\$333.50 per year
Renewal of rollers (Est.).....	\$3.00 per day.
Rate of pay—driver.....	.....

Combination Equipment the Future Type.

Perhaps the type of street-washing equipment which has most in its favor is the combination sprinkler, flusher and squeegee. With such a machine it should be possible to secure the most efficient



21. Special Street Railway Flusher. Note the swinging arm carrying a nozzle which enables the machine to clean wide streets.

cleaning and the greatest economy. One of the weaknesses of flushing is the necessity for leaving the dirt spread over a wide strip next to the gutter, especially on dirty smoothly paved streets which have little crown or grade. By running a squeegee along the gutter after flushing the center of the street, much of this objection would be removed.

Combination equipment has been in use in Europe for several years. (See Photo No. 22.) The first developed for use in this country is now being constructed upon designs drawn for Commissioner Fetherston, of New York City. This will be of the tractor-trailer type, with an 1,800-gallon tank, an electrically-driven pump and either an electrically-driven machine broom or squeegee. The results secured with this machine should be of great interest and value to all large cities.

Discussion Invited.

This paper is submitted with the hope that its contents may occasion discussion of the subject which will be helpful to those interested in the street cleaning field. If experience elsewhere does not support the findings here expressed, the writer urges the reader to make his own experience and ideas available to the New York Bureau of Municipal Research, so that others may be given the advantage of the best experience available.

Acknowledgment is gratefully given to those individuals and



22. Paris Combination Equipment. Combined flusher, sweeper and sprinkler.

companies who have so kindly assisted in the gathering of the data here presented: Commissioner J. T. Fetherston, of New York City; Commissioner H. W. Pierce, of Rochester, N. Y.; Superintendent J. J. Knight, of Detroit, Mich.; Superintendent J. W. Paxton, of Washington, D. C.; Mr. Thomas W. Kennedy, formerly Deputy Commissioner of Streets, Buffalo, N. Y.; Mr. Albert T. Rhodes, Street Commissioner, Worcester, Mass.; Mr. S. B. Whinery, M. E., of New York City; the Bureau of Municipal Research of Milwaukee, Wis.; The Efficiency Department, City of Los Angeles, especially Mr. W. H. Nanry, Investigator; The American Car Sprinkler Company, of Worcester, Mass.; The International Motor Company of New York City; The Sterling Motor Truck Company of Milwaukee, Wis.; The Moreland Truck Company of Los Angeles, Cal., and Charles Hvass & Company, New York City.

REPORT OF THE COMMITTEE ON SEWERAGE AND SANITATION.

George A. Carpenter, Chairman, City Engineer, Pawtucket, R. I.

Because of the great interest of sanitary engineers in the latest developments of Imhoff tank installations and in the activated sludge treatment of sewage, the Committee on Sewerage and Sanitation decided, early in the year, to confine its work to securing papers upon these subjects. The result of its labors is the program of the afternoon. Thanks to the willingness of some of our busy and most prominent sanitary engineers, to give of their time and experience for the benefit of the profession, we have a program covering the very latest developments in sewage disposal methods.

Replying to the committee's invitation to prepare a paper upon certain experiments which were being carried out under his direction, one engineer wrote: "I find that it is not worth while spending the time which it takes to present such a paper unless some discussion is given to it, and unless men able to discuss such a subject are selected by your committee and have a copy of the paper in hand before the convention."

The committee found itself in hearty sympathy with this sentiment and notified that engineer that it would use its best efforts to provide for such a discussion. In accordance with this promise it has invited a few, well qualified engineers to prepare papers upon different phases of the subject and to undertake a discussion of the other papers. It is hoped that this discussion may become general and that those who may not have had sufficient time to study the advance sheets, but later find that they might have contributed to the discussion and those who, possibly, may not agree entirely with the views expressed, will not hesitate to send written discussions to the secretary in time for incorporation in the printed proceedings of the convention.

The committee wishes to emphasize the necessity of an intelligent discussion of the papers presented, arranged for in advance, if en-

gineers of prominence are to be persuaded that it is worth their while to prepare papers for meetings of this character.

The attitude of Mr. Hatton and other engineers, in giving to the profession the best and latest information upon the activated sludge experiments being carried on under their direction, is to be especially commended. Too often do engineers hesitate to publish the results of their experimental work until the value of the process has been established beyond the question of a doubt, in the fear that some statement or deduction may have to be amended or withdrawn.

While the real progress in sewage disposal during the year has been along the lines of activated sludge treatment, it has also appeared to your committee that the trend of the sewage disposal problem has tended to emphasize the fact that what may be termed "the local-conditions factor" in disposal methods is receiving more prominent recognition by the profession. In support of this may be cited the intention at Philadelphia to "divide the city into three main drainage areas" and to provide such methods of treatment at each of the three disposal works as the particular drainage area tributary thereto may demand, in all cases "utilizing to the highest possibility the great diluting and oxidizing power" of the Delaware river.

At Cleveland it is to be noted that the latest plans provide for differing methods of treatment for the sewage coming from different sections of that city. Even New York City is reported as considering the advisability of disposing of some of its sewage, at least, at local treatment stations built under the streets at existing sewer outlets. This, says the *Municipal Journal*, "is due not more to improvements in methods than to changes in aims; for the effluents from plants such as those contemplated in New York may contain ten times as much organic matter as those from good intermittent filters, and yet be considered satisfactory."

It is manifest also that there is a general feeling among engineers that the last word in sewage treatment methods has not yet been spoken and many plants are being designed that progressive steps in treatment may be used, and an adaptability of the plant to possible future developments in methods is being given careful study. As the author of one of the papers puts it, "it is notable, that in the

midst of all our enthusiasm for this method of sewage treatment (the activated sludge process), a studious reserve is maintained as to the general outlook."

It is very generally recognized that the activated sludge method is yet in the process of development and should not be adopted except under expert advice. Thus far the conditions necessary for success have not been sufficiently standardized to justify the adoption of this method by small communities and the great problem with reference to it today is the question of cost.

In view of the list of papers to be represented, further comment by the committee upon the latest methods of sewage disposal seems unnecessary.

Respectfully submitted,

GEO. A. CARPENTER, *Chairman.*

FRANK A. BARBOUR.

GEORGE C. WHIPPLE.

SEWAGE TREATMENT BY AERATION AND ACTIVATION

*By George T. Hammond, Engineer of Design, and in Charge of
the Sewage Experiment Station, Bureau of Sewers,
Boro of Brooklyn, N. Y.*

By far the most interesting development in methods of treating sewage brought forward in recent years is that known as activated sludge, a name invented by Dr. Gilbert Fowler, of Manchester, England, to describe a process which, altho as yet within the region of study and experimentation, has already taken its place among approved methods of sewage treatment and promises possibly to occupy the entire field if the problems connected with it can be solved by a more extensive general experience in its application. It is admitted that there are still many things to be learned about it and difficulties to be overcome, but it may be said justly that it gives at present great promise.

It is the purpose of this paper to present from an engineer's standpoint a general review of the subject from the beginning if possible, and point out the progress made up to this time, to cover the field in a broad manner, so as to invite discussion by our sanitary engineers and especially those who have been studying its special details. Other papers will be presented to this convention which will go more into detail concerning important technical features, and the aim is not to touch upon the field covered by these papers. Another purpose is to trace the growth of the ideas and discoveries which have led up to the method now known by the name "activated sludge;" and to call attention to the large part of the credit which is due to American scientists and engineers.

Mr. William R. Copeland, of Milwaukee, has defined the activated sludge process as follows:

The sludge embodied in sewage and consisting of suspended organic solids, including those of a colloidal nature, when agitated with air for a sufficient period assumes a flocculent appearance very similar to small pieces of sponge. Aerobic and facultative aerobic bacteria gather in these flocculi in immense numbers, from twelve

to fourteen millions per c.c., some having been strained from the sewage and others developed by natural growth.

Among the latter are species which possess the power to decompose organic matter, especially of an albuminoid or nitrogenous nature, setting the nitrogen free; and others, absorbing this nitrogen, convert it into nitrites and nitrates. These biological processes require time, air and favorable environment, such as suitable temperature, food supply and sufficient agitation to distribute them thruout all parts of the sewage.

In the course of commenting on the above description, Mr. T. Chalkley Hatton remarks:

It has been known for generations that air was one of the most important agents for the destruction of putrefactive organic matters; that if you could give the foulest sewage a given volume of air during an extended period, all of the organic matters would be oxidized, and a stable effluent would result.

It has long been common knowledge among sewage disposal engineers and sanitarians that sewage and similar liquids can be purified by the artificial application of natural oxidizing agencies and the cultivation of bacteria in the presence of air applied by various means, including forced aeration with compressed air. Whatever the design of the apparatus for the application of the air, the essential process of purification would seem to be the same, and to consist mainly of biochemical oxidation of the organic impurities present in the sewage.

In 1884, Dupre and Dibdin experimented with direct or forced aeration and concluded that it had but little effect on sewage; notwithstanding this, a patent was issued in England in 1888 for treating sewage by blowing air thru it.

In 1890, Dr. T. M. Drown, for many years chemist to the Massachusetts State Board of Health, and Prof. Leeds, from investigations concluded that oxidation of organic matter in water is not hastened to any great extent by aeration and agitation. Col. George E. Waring became convinced that aeration if properly applied to sewage afforded a practicable means of treatment. Probably the first sewage-treatment plant in America upon a working scale in which aeration was employed as an important feature, was designed by him, and constructed at Wayne, Pa., in 1894. Other

plants were constructed in which air was employed, among them being the "Homewood" plant in Brooklyn, constructed at about the same time as that at Wayne but now for several years dismantled.

It is well to recognize the relation which naturally exists between the various methods of sewage treatment and to observe that the end to be secured is usually the same, and consists of stability in the effluent.

The essential feature of the so-called "activated sludge" process of sewage purification is the artificial application of well-known natural biological agencies, which in the presence of an abundant supply of atmospheric oxygen produce biochemical changes in the organic matter in the sewage and render the sewage "stable."

This result is obtained by the biological oxidation of organic impurities which are decomposable. The oxidizing bacteria obtain their food supply and the energy employed in their life processes from the organic material in the sewage, which in the presence of atmospheric oxygen they rapidly attack and oxidize.

For many years the principal object of sanitary engineers in the design of sewage treatment and disposal plants, has been to bring together in the most suitable and efficient manner, the decomposable materials, the oxidizing bacteria and an abundant air supply for the bacteria. All forms of sewage disposal on land, the method known as broad irrigation, or sewage farming; all filtration methods, such as sand filters, the percolating or sprinkling filters called in England "bacteria beds," contact filters, etc., no less than the various forms or methods of treatment using compressed air forced into sewage in tanks or in filter beds, depend upon this fundamental principle, which is also nature's principle, by means of which brooks, streams, rivers, ponds, and indeed all natural waters are purified. This principle, in short, consists of the biochemical oxidation of the decomposable materials present in foul water or sewage.

Since the discovery of oxidizing bacteria, there has been a continuous evolution or progress in the growth of scientific knowledge on this subject, to the investigation of which some of the foremost scientists have given their unremittent efforts.

In America, the Massachusetts State Board of Health was the

pioneer and its work is known thruout the world. In 1890 this board published a special report in which experiments are described which were begun in 1888. This report is generally acknowledged as the starting point from which all efforts to apply biochemical methods of treating sewage originate. It demonstrated that sewage could be successfully purified by biological agencies, and that the principal problem remaining was the proper design of plants for the employment of these agencies.

Writing on this subject previous to 1911, Prof. Earl B. Phelps prepared the following for Marshalls' work on Micro-biology. I extract as follows from the captions, "Oxidizing Bacteria" and "The Cultivation of Sewage Bacteria."

There are two general methods employed for the cultivation of those bacteria which are of assistance in sewage purification.

They may be cultivated in so-called filters of sand or coarser material, or in specially constructed tanks, such as the septic, or the hydrolytic tank.

In the former case the bacterial growth occurs upon the special medium provided, the sand or stone; in the latter, it takes place in the liquid itself, and a continuous life history within such a tank is possible only when the rate of flow is sufficiently slow to permit of the inoculation of the incoming stream by the contents of the tank.

A filter is a biological culture medium upon which the various types of bacteria are growing and carrying out their functions. * * * The sewage trickles slowly over the surfaces (of the filter medium) or is held in contact with them temporarily, according as we are dealing with trickling or contact filters; solids adhere to the stones or settle upon them, and soluble material is adsorbed by the surface growths and removed from solution. Within these gelatinous growths (on the media) to which the air also has free access, the processes of oxidation take place, and the products, the semi-oxidized organic material, are later shed from the stones, appearing again in the effluent as stable organic matter.

The method of applying the treatment, or the design of the plant in which it is applied, does not alter the essential process of oxidation.

Aside from the mere effect of agitation caused by the air in a filled tank, aeration of sewage by means of compressed air, is,

it would seem, a reversal of the method by filtration. In the former, the bacteria are not only afforded their necessary oxygen by the compressed air, but they are moved up and down thru the liquid, and brought into contact with it, until the entire liquid is caused to have the greatest possible number of these agents of oxidation within it; and they have, by their life processes, converted the unstable organic contents into a stable condition.

In the filter the same result is secured by supplying the sewage to a bed of sand, or of broken stone, the particles of which are surrounded with films, formed of bacterial and other growths, over which the sewage percolates in the presence of abundant atmospheric air. The liquid in passing thru the filter flows over the surfaces of the medium; and the more vascular the character of the latter the better.

Mr. O. J. Wilkinson, of Manchester, Eng., in a letter relative to activated sludge and sewage aeration, (see *Engineering News*, Nov. 11, 1915), says in part, as follows:

On starting up a new filter the sewage shows but little change after passing thru; but as time goes on a growth shows itself in the body of the filter, in what may be termed the stationary framework; and colonies of bacteria accumulate there which attack the sewage and effect purification or oxidation of the organic matter.

These bacteria being mainly aerobic, an ample supply of air is necessary in order that they may thrive; hence the necessity for adequate ventilation of the underdrainage. * * * Let us take a given volume of the stationary framework from a pipe filter and carefully remove the coating, or growth, thru the material. We shall then have a certain volume of what may be termed sludge, rich in aerobic bacteria, which may be referred to as the activated sludge of this particular process. In the new process (activated sludge) the active sludge is circulated thruout the sewage in the presence of air, as against the present day practice of passing sewage in thin films over active sludge retained on a stationary framework, as, for example, in the case of percolators.

The real problem then is as follows: To ascertain the most economical method of applying air to sewage with maintainance of complete circulation of the activated sludge without any formation of dead banks of material. The problem may now be said to resolve itself into one of reproducing in a tank the changes which take place in a percolating filter. We have our tank, which represents the walls and floor of the filter, we have our colonies of

bacteria, and the air necessary to support their life; and what we require to do is to provide means for supporting an even distribution of this life thruout the body of the tank, other than by allowing the bacteria to adhere to a stationary framework such as stone, slate, or clinker material. Compressed air will both insure sufficient agitation and effect the desired results, as regards preserving uniform contact and even distribution in the liquid.

The application of this method to sewage purification has been effected by various designs of apparatus. In general, these may be classed in two main divisions:

First: Apparatus in which the atmospheric air is employed without compression, i. e., at ordinary atmospheric pressure.

Such apparatus includes the well known forms of filtration, sand filters, percolating filters, sprinkling filters, etc.

Second: Apparatus in which the air, compressed by various means, is applied to sewage contained in tanks, filter beds, etc., or even during its passage thru closed channels, such as pipes, siphons, etc.

Such apparatus includes the various forms of aerating tanks, aerated contact filters, tanks similar to the Lawrence tank, provided with slate colloiders, and the Black-Phelps type of aerator tank, containing lattice-work discs placed at right angle to the direction of the entering air. Also the Beddoes method of employing the flowing stream of sewage to compress the air used to aerate it; for which a United States Patent was granted in 1908, and which has been installed in several places visited by the writer, as well as at the Brooklyn sewage experiment station.

It is probable that the patent referred to covers apparatus only; but the process described in which the apparatus is used applies compressed air to sewage for the purpose of obtaining biochemical oxidation of the organic matters present, and in some ways seems to anticipate various features of all of the different methods of sewage aeration treatment since proposed.

The apparatus described in this patent, and the necessary tank arrangement for its installation, is undoubtedly capable of producing activated sludge in cases where a sufficient head is available for the satisfactory operation of the siphon air compressor, which

is its most essential feature. As an activated sludge process it would probably not, however, be a great success. It does not cover the returning of any of the settled sludge to the aerated tank. Notwithstanding this, it is interesting to observe that it covers a continuously flowing aeration process, with a settling tank as a final provision. Its importance to us is, however, historical rather than practical.

The principal claims of this patent are:

Claim No. 1. "The herein-described process of treating sewage for the purpose of supplying the same with oxygen to support bacteria, which consists in supplying air or gas to the sewage and subjecting the sewage and air or gas to pressure at the same time."

Claim No. 5. "The herein-described process of treating sewage which consists in supplying the same with oxygen to support bacteria by supplying air or gas to the sewage, subjecting a moving body of sewage and air or gas to pressure at the same time, and then subjecting the sewage so treated to bacterial action in a state of rest."

The Beddoes patent was granted Aug. 4, 1908, having been applied for in March of that year. It is Patent No. 895,229. Cecil C. E. Beddoes, the patentee, was a resident of the state of Pennsylvania.

In January, 1910, the Board of Estimate and Apportionment of the city of New York secured the professional services of Colonel (now General) William M. Black, Corps of Engineers, United States Army, and of Prof. Earle B. Phelps (now professor of Chemistry, Hygienic Laboratory, United States Public Health Service, Washington, D. C.), to conduct some investigations and make a report relative to the problems of sewage treatment, and the discharge of sewage into the harbor and rivers of the city.

In connection with this work Messrs. Black and Phelps commenced experiments relative to sewage treatment in February, 1910, at the Twenty-sixth Ward sewage plant in Brooklyn. The most interesting results secured proved that the treatment of sewage by forced aeration with compressed air was feasible and sufficiently promising for immediate adoption and installation at the Twenty-sixth Ward sewage plant, then treating about 15,000,000 gallons of sewage daily by lime precipitation. The report of these investi-

gators was made to the Board of Estimate and Apportionment February 16, 1911. The high standing of these gentlemen and the thoroughness of their work, as well as the important results achieved and admirably set forth, gave this report widespread attention and led to further investigations, both in this country and abroad.

The Black and Phelps experiments were about the earliest that indicated that a method had been obtained of treating sewage successfully with compressed air. The resulting purification was sufficiently high and the cost appeared to be reasonable. These experiments found it possible to reduce the demand of sewage for oxygen 33 to 50 per cent in a retention period of three hours by using two volumes of air per volume of sewage.

Aeration experimental work received a new impetus at the Lawrence Experimental Station in 1911, and in the fall of 1912 the latter station was visited by Dr. Gilbert Fowler, of Manchester, Eng., who, upon his return to England, in connection with Messrs. Ardern and Lockett, began experiments with the aeration of sewage, which later developed into the so-called "activated sludge" process of treatment.

Concerning these experiments, Dr. Fowler made the following statement in the course of his discussion of the paper presented by Messrs. Ardern and Lockett, in which this work and its results was described:

It is only right to admit that the illuminating idea, which originated the work, was due to the visit he (Fowler) had paid while in the United States to the Mecca of sewage purification, namely, the experiment station at Lawrence, in the State of Massachusetts, where he saw the bottle, described in the paper, in which sewage had been completely purified by 24 hours' aeration.—(*Journal Soc. Ch. Ind. Manchester, Eng.*, May 30, 1914.)

Regarding the work of Messrs. Ardern and Lockett, it may be said briefly that this was commenced in 1913 and consisted of a long series of studies and experiments. It was found at first that, in order to completely nitrify the average sewage of Manchester, it was necessary to apply continuous aeration for five weeks. The sludge remaining, however, after this long period was left in the aerating vessel and allowed to mix with a new filling of crude sewage. This resulted in a much shorter period of aeration, indi-

cating that the sludge from the fully nitrified sewage had become invested with a potential activity by means of which the time of nitrification was greatly shortened. Proceeding along the line suggested by this result, a larger and larger amount of active sludge was accumulated until at length "it was established that a well nitrified effluent could be obtained by six hours' aeration of Manchester sewage in intimate contact with one-fourth its volume of activated sludge."

The air in these laboratory experiments was blown thru plain pipes, and under these conditions it was necessary between the doses of sewage to subject the activated sludge to a further intermediate period of aeration.

As these first experiments were only on a laboratory scale, it was considered advisable to try them out with larger aerating units. For this purpose casks of 50-gal. capacity were employed, and the air was applied thru porous tile, placed in the bottom of the cask. It was found that four volumes of crude sewage to one volume of activated sludge, aerated with 15 cu. ft. of compressed air per hour per square foot of floor space for from four to six hours, followed by a sedimentation period of from one to two hours, gave a result ample to assume a thoroly stable effluent.

Progress with the new method in England has been checked by the war, but studies are being made for several installations. At Worcester half of the sewage of the city is to be treated by Messrs Jones and Attwood, of Stourbridge, by this method, and at present about 1,000,000 gallons a day are being treated under this contract, which provides that not more than four parts per 100,000 of suspended matter shall be present in the effluent, and shall be non-putrefactive, a condition that is being successfully complied with.

Following the work of Messrs. Ardern and Lockett at Manchester, the process now christened "*activated sludge*" was tried out on a larger scale at Salford, Eng., by Messrs. Melling and Duckworth.

There were already existing at the Salford plant six roughing filters, 18,000 sq. ft. in total area, filled to a depth of 2 ft. 6 in.

with river gravel, and equipped with a net work of air pipes with $\frac{1}{2}$ in. brass jets, each bed having about 15,000 jets.

One-third of one bed, or 1,000 sq. ft. with 5,000 jets, was converted for the purpose of aeration experiments by the removal of the gravel, and introduction of brick filling close up to the air pipes, so as to prevent stagnation of sludge below the air entrances.

For the first experiments half of this converted section was used, thus forming a tank of 12,500 gal. capacity. This tank was operated a month on the gradual sludge-accumulation plan of the previous laboratory experiments, consisting of the fill, aeration, settlement, and discharge of the supernatant clear liquor, the settled sludge being retained, then the tank refilled with sewage and the cycle repeated.

At the end of a month it was decided to accelerate the accumulation of activated sludge, and this was accomplished by activating washed final humus. During this period, which occupied another month, aeration was continued without replacing the sewage. Fillings with sewage were then recommenced and the tank was operated on a fill and draw cycle with three hours for aeration and two hours for settling the treated contents of the tank.

These experiments demonstrated the feasibility of the fill and draw method on a large scale, and definitely confirmed the previous laboratory experiments.

The demonstration, however, was as yet only of the principle involved, and not as to its probable cost or the practical methods of design and operation required for its general employment. But its promise as a method of sewage treatment seemed obvious.

The reports of the English experimenters were received with great interest in America. The writer's attention was called to the paper of Ardern and Lockett by Mr. W. L. Stevenson, of Philadelphia, and by Prof. Earle B. Phelps, late in the fall of 1914. Meanwhile Mr. H. C. McRae, of Baltimore, had become informed of these reports, and had communicated them to Mr. Leslie C. Frank, of the U. S. Public Health Service. At about the same time Mr. T. Chalkley Hatton had got into touch with Dr. Gilbert

Fowler, of Manchester, and had secured his co-operation in conducting experiments at Milwaukee.

The first work of which the writer has knowledge was, however, conducted by Prof. Edward Bartow at Urbana, Ills., who started his aerating tank Nov. 21, 1914. At Lawrence, Mass., H. W. Clark started an activated sludge tank in February, 1915. Experiments were commenced with this method early in March, 1915, at Baltimore, Milwaukee and Brooklyn; at Chicago, by the Sanitary District, in May; and at Regina, Sask., Canada, May 18; Houston, Texas, began experiments in September.

The foregoing are among the places where experiments were conducted, but there are a number of others; and, as *Engineering News* remarked in a recent editorial:

Activated-sludge plants from ocean to ocean, and from the lakes to the gulf, will be in operation within a few months, if present plans are carried out. Milwaukee and Cleveland have had in use for some months working-scale units, which are the beginning of proposed large installations. Baltimore has adapted some of its Imhoff tanks to the activated sludge process for working-test purposes. The Brooklyn sewer engineers are giving close study to the new process, as also the staff of the Lawrence experiment station. Tests at several different plants in Chicago are being made by the Sanitary District, and by packing house companies. The Illinois State Water Survey experiments at Urbana are being continued in a comprehensive and promising way. A plant is being built, if not already in use, at Houston, Texas. Plans for a plant in New Jersey have been approved by the State Department of Health. An Engineer has recommended Riensch-Wurl screens and activated sludge tanks for Lima, Ohio. Most recent of all, the authorities of Hermosa Beach, California, have decided to build an activated sludge plant. * * * Should its highest promises be realized it will fall little if any short of revolutionizing sewage disposal. As yet there is need for caution. Many details of design and operation remain to be worked out, or where already worked out, chosen from after further experience.

It is notable, that in the midst of all our enthusiasm for this method of sewage treatment, a studious reserve is maintained in every paper describing experiments, as to the general outlook. No one is ready to advocate the installation of such a plant without at the same time adding that there are many unsolved problems connected with it and its economic features.

"As yet there is need of caution;" as yet we have much to determine before we can be certain of the best design, or of the probable cost of operation; not to mention the attendant problem of sludge drying and disposal.

It is now nearly two years since the method was announced, and studies have multiplied relative to it; what, may we ask, is its present status, what are the main problems as yet unsolved or not completely solved?

At the Pittsburg convention, held in June of this year of the American Society of Civil Engineers, an informal meeting occurred of members and associate members of the Society, interested in sewage disposal. There were thirty-two members present, and the problems associated with activated sludge were considered and discussed so fully that the report prepared to cover the work of the meeting affords an excellent summary of the problems involved, so far as at present understood. We add such part of this report as seems of interest in this connection.

It should be observed, however, that some of the problems stated are near solution or have already been fairly solved, while some are not stated that might have been, especially the problem of operation cost, etc.

But it was understood that the committee appointed by the meeting would attempt to investigate all such problems, whether mentioned at the meeting or not.

The purpose of the meeting was stated by Mr. T. Chalkley Hatton, to-wit:

1. To discuss the problems connected with the treatment of sewage by the activated sludge process.
2. To compare results obtained from the several experiments carried out in the United States and Canada.
3. To harmonize those results with a view of determining the causes for the variance.
4. By co-operation to determine, if possible, the following questions:

A.—Most efficient depth of aerating tanks.

B.—Most efficient type of aerating tank, embracing, a—baffles, b—unbaffled, c—bottom cross-section, d—circular or rectangular.

C.—Most efficient method of diffusing air, embracing, a—open-air pipe, b—perforated or woven metal disks, c—stone ware, d—wood plates.

D.—Probability of diminishing efficiency of air diffusers, and consequent necessity for providing appliances and facilities for cleaning same at intervals.

E.—Most efficient type of sedimentation tanks, embracing vertical flow and horizontal flow and probable velocity in each to effect satisfactory precipitation.

F.—Best method for removing sludge from sedimentation tanks, and regulating the volume to be returned to the aerating tanks.

G.—Volume of dry sludge (10 per cent moisture) secured per million gallons of sewage treated.

H.—Removing surplus sludge from sedimentation tanks and dewatering, a—subsequent settlement under water pressure, b—pressing, c—centrifuging, d—fermentation, e—absorption, f—natural drying, g—artificial drying.

I.—Marketing sludge.

J.—Standardization of terms in the activated sludge process with a view of comparing results, embracing, a—air used per gallon of sewage treated, or per square foot of tank surface, or other standard, b—diffusion area per square foot of tank surface, or per cubic foot tank capacity, or other standard, c—volume of activated sludge contained in aerating tanks, whether to express it in terms of percentage, or otherwise, and how to determine such percentage; that is, after one-half hour's, one hour's or longer, in test tube, d—quality of activated sludge returned to aerating chamber, whether to be measured by nitrate or bacterial content or otherwise, e—volume of surplus sludge removed to be stated in weight per million gallons of sewage treated with moisture content stated, or on a basis of 10 per cent moisture, or otherwise, f—putrescibility percentage, whether based on 5, 10 or 20 days or otherwise, g—such other standardizations as may seem desirable.

The question was discussed of effecting a permanent organization for systematically co-operating in solving the several problems of the activated sludge process so as to avoid duplication of experiments thruout the United States and Canada, and also to protect the process from being controlled by patents issued without com-

plete information having been submitted to the Commissioner of Patents by those who had knowledge of the process prior to the application for letters patent.

It was finally decided that this was not the proper time for effecting such an organization; that the objects sought could best be obtained for the present thru a committee and individual service, and upon motion of Prof. Earle B. Phelps a committee, composed of F. A. Dallyn, Provincial Sanitary Engineer, Toronto, Canada; George T. Hammond, Engineer of Design, Boro of Brooklyn, and T. Chalkley Hatton, Chief Engineer, Sewerage Commission, Milwaukee, was appointed for the following purpose:

First: To prepare standard definitions and other terms relating to the activated sludge process of treating sewage.

Second: To tabulate and distribute a summary of work now being done, or contemplated.

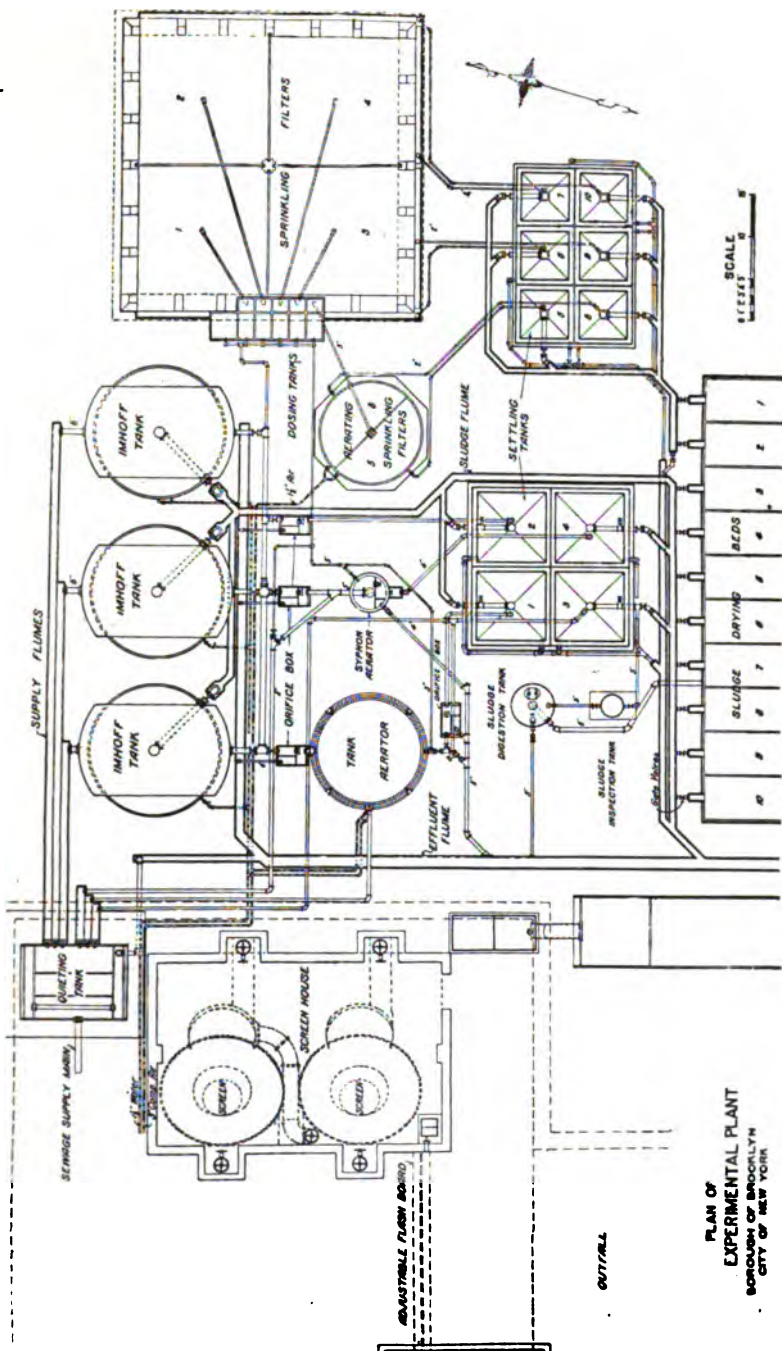
Third: To suggest such correlation of the work being done as may from time to time be desirable.

Taking a broad view of the field, it is of much interest to observe the work being done by the several investigators and scientists who are making a study of this method of treating sewage; and the outlook is quite encouraging, the more so as it is seen on every side that the problems, both scientific and practical, are being well recognized and given very careful study.

Looking over the field more in detail, it will be of interest to give a rather rapid survey of the work already accomplished and under way. The writer visited, early in the present year, the plants at Baltimore, Milwaukee, Chicago and Cleveland, and has recently received information from all of these plants and from most of the other plants working on this problem. Before presenting the data thus obtained, a brief review of our work in Brooklyn will be given.

THE BROOKLYN SEWAGE EXPERIMENT STATION, 1913-1916.

By resolution, dated April 18, 1912, sewage treatment experiments were authorized by the Board of Estimate and Apportionment on a rather liberal scale and an experimental plant was provided for to be installed at the Twenty-sixth Ward sewage works.



The purpose was to cover a more extensive field of investigation than had been covered by Messrs. Black and Phelps, as well as to repeat their experiments on a larger scale.

All of the standard forms of sewage disposal apparatus were included in the design of the plant, as well as several units for treatment by forced aeration, employed by Black and Phelps. It was possible, therefore, at this plant to compare the phenomena presented by sewage filtration and forced aeration and to observe their similarity in biological principles and process.

For the purpose of providing the plant and making the tests \$50,000 was made available.

The design of this experimental plant as well as its operation was assigned to the office of the Boro President of Brooklyn, and given to the Bureau of Sewers, of which Mr. E. J. Fort was then, and still is, Chief Engineer, and the writer was, as he still is, Engineer of Design. The writer was given immediate charge of this work, both as to the design of the plant and the carrying on of the experiments.

Previous to preparing the design of the plant, Mr. Fort and the writer visited England, Germany and France for the purpose of making a study of every important sewage disposal plant, and the processes of sewage treatment employed in each. Previously nearly every important plant in this country had been visited and studied.

Work was begun on the design of the plant in July, 1912, and completed in January, 1913. The plans were officially approved February 10, 1913. Work on the construction of the plant began in March, 1913, and as soon as the different units were completed they were put into service.

The entire plant was in service in the autumn of 1913, and experimental work has continued up to the present time. The aeration units were among the first to be designed.

A descriptive account of this plant was prepared by the writer and presented as a paper at Convention of the American Society of Municipal Improvements at Boston in October, 1914.

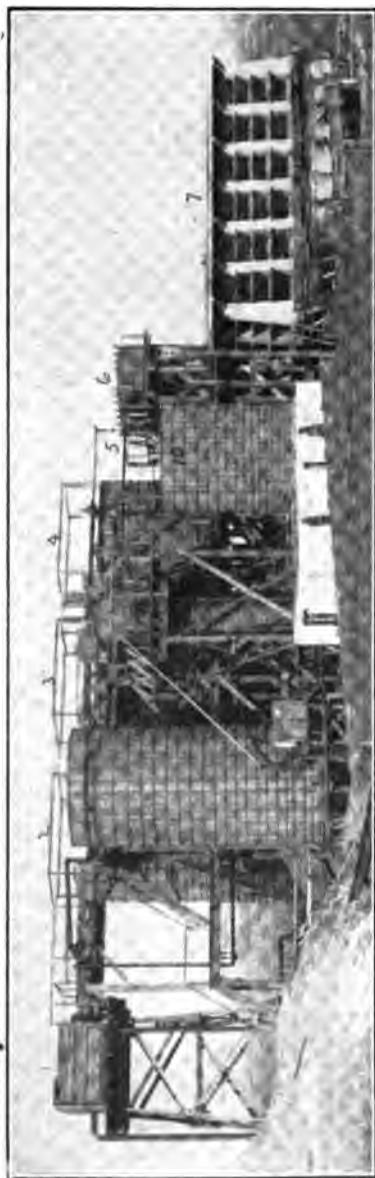


Fig. 2. Experimental plant from the south showing (2) aerator tank, (3) siphon aerator, (5) aerated sprinkling filter.

The principal aeration methods of sewage treatment provided for in this plant were.

First—The Black and Phelps method as described in their report to the Board of Estimate of this city in February, 1911. This method developed into the so-called "activated sludge" method, using the original apparatus.

Second—Sprinkling filters and contact beds with forced aeration applied by compressed air.

Third—The Beddoes method of sewage treatment.

As one of the principal objects contemplated in the design of this experimental plant was to take up the work of Messrs. Black and Phelps and carry it forward, for this purpose a 16,000-gal. tank, arranged for aeration experiments and named the tank aerator, the design of which met the approval of Professor Phelps, was put in service in the fall of 1913 as a continuously flowing sewage aerator. This tank was so connected to the system that it could be operated either by the continuous flow or by the fill-and-draw method, and could be supplied either with crude sewage or with the effluent from Imhoff tanks. Sewage was introduced at the top and withdrawn from the bottom, tho this method of operation could be reversed. The crude sewage was supplied by gravity from the sewage supply or quieting tank that served the experimental work of the station. It was pumped from the sewer by a reciprocating pump and was detained less than five minutes in the quieting tank. Compressed air was supplied by a duplex air-compressor of ample size, installed as part of the experimental plant.

The tank aerator was 12 ft. in diameter and 25 ft. 8 in. in depth. A grid for supplying compressed air was placed at the bottom of the tank, supported by $7\frac{1}{2}$ in. of broken stone, which passed a 2-in. but was retained by a 1-in. ring. An equal depth of broken stone of the same size was placed over the grid, so that the air first passed upward thru the voids in the broken stone. Thus the entire bottom of the tank was occupied by what may be considered a coarse porous disk 12 feet in diameter and 15 inches thick, thru which air was supplied to the sewage. The outlet of the tank, as originally installed for sewage-aeration experiments, was about one foot above the surface of the broken stone, so that one-twentieth to one-twelfth



Fig. 3. Brooklyn, N. Y. Experimental plant from the west, showing supply pipe to aerating tank, etc.

of the contents of the tank was retained at each emptying. Another outlet was provided about one-third of the depth above the bottom of the tank for activated sludge experiments. A lower outlet was provided for draining the lowest level of the tank. The compressed air grid consisted of two $1\frac{1}{2}$ -in. pipes crossed at right angles in the center. The arms of the cross were connected with quarter circles of $\frac{3}{4}$ in. pipe to form five concentric rings, each of which was perforated at 6-in. intervals with $1/16$ -in. holes. The air, entering thru $1\frac{1}{2}$ -in. pipes, was thus distributed to the rings and discharged into the broken stone surrounding the grid. Nine deflector discs, supported by a vertical 4-in. pipe in the center of the tank, formed a feature of the tank. The discs were in form not unlike wheels; the supporting pipe passed thru their hubs. The surface of each disc was horizontal, and occupied the entire cross-section of the tank, which was thus divided into story-like compartments. They were designed to deflect the downward flow of sewage in order to prevent downward streaming and to equalize and give a sinuous motion to the upward flow of air; thus more even distribution of both air and sewage was secured. As stated above, they were each made in the form of a wheel, supported on six arms, between which were slats, radiating from the iron hub of each disc. The slats were set in grooves in the arms, with a dip of 45° . The slats in alternate discs were set sloping from and toward the center.

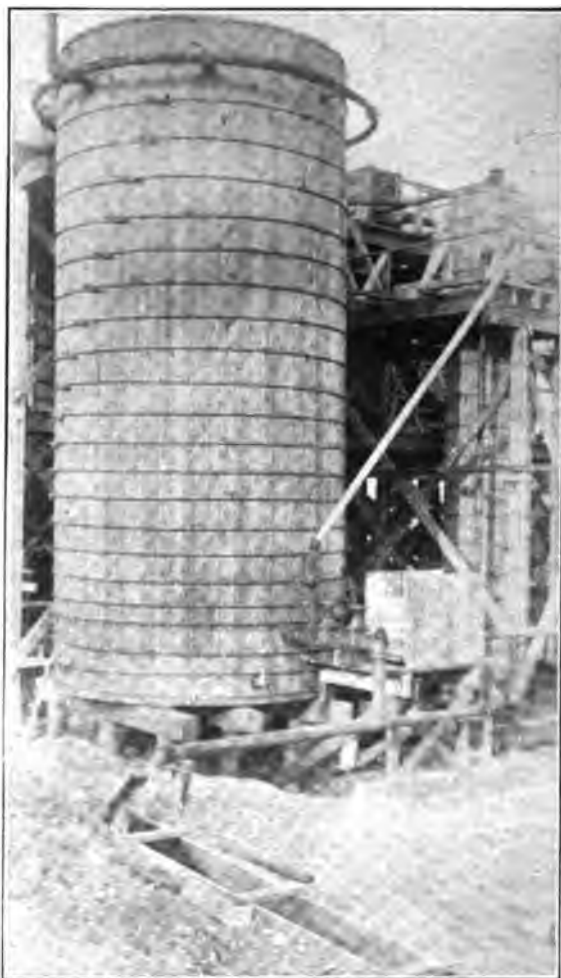


Fig. 4. Brooklyn, N. Y. Aerator tank as used in 1913 and 1914, equipped for continuous flow treatment of sewage by forced aeration.

This aerating tank followed the design used by Messrs. Black and Phelps in 1910 in their deep-tank experiments, a description of which is given on page 72 of the report of these investigators to the Board of Estimate and Apportionment of the City of New York.

The first experiments, in 1913, on the continuous-flow plan with plain aeration of sewage in the tank aerator, were made with an



Fig. 5. Brooklyn, N. Y. In the foreground is shown one of the nine deflector discs ready for placing in the aerator tank, also the broken-stone which was used to support and cover the pipe-grid installed for supplying compressed air.

air supply of 0.75 volume per volume of sewage and 2-hr. retention period. This it was considered would be the minimum treatment. It was insufficient to produce any marked result. The retention period was, therefore, doubled, but with little improvement. A greater volume of air was then applied, but the result was not satisfactory, and the results secured were not even promising during the winter and early spring of 1914. As it was thought that the tank would work better after it had been thoroly seeded with aerobic bacteria, the continuous-flow method was suspended, and the sewage was retained in the tank under aeration for 24-hr. periods, the fill-and-draw method of operation being followed. Some phenomena of activated sludge were observed at this stage of the experiment, but not then recognized as being important. This method of ripening was carried on until June 14, when apparently the tank had ripened, and a fine, clear effluent could be obtained with certainty from crude sewage or Imhoff tank effluent on the fill-and-draw plan with 24 hrs. aeration.

Return was then made to the continuous-flow method, and operation was commenced with 3.25 volumes of air per volume of sewage with 5-hr. tank retention. This gave a highly clarified effluent, but not of satisfactory stability. The retention period was increased



Fig. 6. Brooklyn, N. Y. Top of aerator tank and surface of aerated sewage during continuous-flow operation in 1914. Large masses of foam were often present as shown. The wind has blown the foam to one side of tank, aerating the surface of the sewage at the other side.

to 24 hrs., with the same rate of air flow per minute, the air supply being thus increased to 18 volumes per volume of sewage. The effluent, after passing a settling tank with 3-hr. retention, then showed a quality comparable with that from a sprinkling filter. Its average relative stability was 84 per cent. The quantity of air was later reduced, October 1, to 9 volumes per volume of sewage treated, the continuous-flow plan being retained. Under these conditions the relative stability of the settled effluent fell to 59 per cent. This work was continued until it seemed to be demonstrated completely that tho a satisfactory effluent could be obtained the cost of air made the treatment for obtaining the same grade of effluent more expensive than treatment by the sprinkling filter.

Table I shows the average of results of operating the tank aerator to October 1, 1914, on the continuous-flow plan. Of course, some activated sludge may have been present, but if so, we had then no knowledge of that method, as distinguished from our own.

TABLE I.

Results of Operating Tank Aerator on Continuous-Flow Plan.

(Parts per Million Except as Otherwise Designated.)

Period of retention in tank aerator, 24 hours. Amount of crude sewage treated in 24 hours, 16,000 gallons. Air applied, 2.3 cu. ft. per gallon. Settlement period of effluent in settling tank No. 1, 3 hrs. 12 min.

	Crude sewage	Tank aerator	Settling Tank No. 1
Settling matter (cc. per liter).....	2.3	5.4	0.2
Total suspended solids.....	164	103	40
Volatile suspended solids.....	130	79	30
Total oxygen consumed.....	58	39	26
Dissolved oxygen consumed.....	37	27	22
Total dissolved oxygen.....	1.4	3.1	1.1
Dissolved oxygen demand.....	191	55	31
Relative stability (percentage):			
Undiluted	2	43	84
Diluted 1:10 with distilled water.....	35	94	100

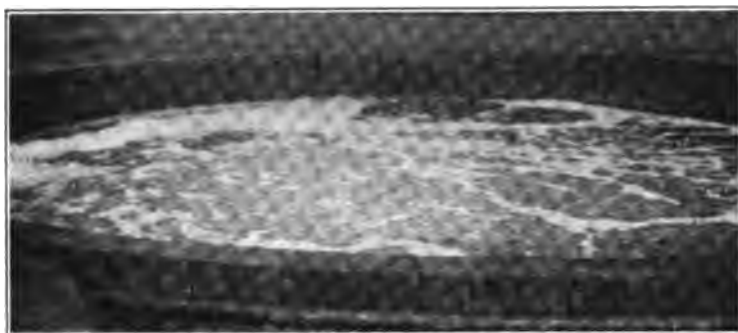


Fig. 7. Brooklyn, N. Y. Top of aerator tank and surface of aerated sewage during operation with activated sludge in 1915. Distribution was very regular.

As experiments in sewage aeration with activated sludge characterized our work during 1915, the experiments of Fowler having been brought to our notice in the late fall of 1914 by Prof. Phelps, the aerator tank was started in March as an activated-sludge tank, the only change made in the tank being to use a higher outlet which retained the sludge falling beneath it. The accumulation of activated sludge, which had been commenced about the middle of March, was sufficient to permit regular operation of the experimental unit by the middle of May, but it was thought best to continue until June 1st, on which date the tank was put into service on a regular cycle of operation. The cycle began with a period of sedimentation,



Fig. 8a. Brooklyn, N. Y. Top of continuous-flow Imhoff-type activated sludge treatment plant, 1915-1916. The flowing-thru chamber acts as a quieting and settling tank. The clearness of the contents is shown by thrusting a rule into it, which is visible thru the water.



Fig. 8b. Top of continuous-flow tank, showing quiet contents of flowing-thru chamber, and turbulent contents of the tank outside of the chamber. Algae growths are shown along the side wall of the chamber, which are clearly seen at considerable depth thru the settling sewage.

during which the air was shut off, followed by a period of discharge, which continued $1\frac{1}{2}$ hrs., when refilling began and the air was turned on. Refilling continued for $1\frac{1}{2}$ hrs., and aeration was continued for a period of 20 hrs., when the cycle began again. The air was measured by a Venturi meter, devised for the purpose. Both influent and effluent sewages were measured. The results in averages for June, July and August, 1915, are shown in Table II.

TABLE II.

Results of Sewage Aeration in Presence of Activated Sludge on Fill-and-Draw Plan.

		(Parts per Million.)				
Determination	Month	Crude sewage	Hours after Refill			
			0	2	5	20
Suspended solids	June	180	35	24	20	14
	July	147	21	12	9	14
	August	154	24	12	8	6
Dissolved oxygen	June	1.0	0.0	0.1	0.4	2.5
	July	0.7	0.0	0.0	0.2	1.7
	August	0.5	0.0	0.0	0.1	0.9
Relative stability	June		14	31	76	100
	July		11	34	84	100
	August		12	28	63	88
Oxygen demand	June	230	53	38		7
	July	173	63	38		4
	August	211	53	34		11
Nitrite	June		0.08	0.11	0.49	1.50
	July		0.01	0.07	0.25	0.53
	August		0.00	0.07	0.12	0.66
Nitrate	June		0.10	0.60	1.20	7.30
	July		0.00	0.10	0.55	2.80
	August		0.00	0.10	0.55	2.80
Volumes of air per volume of sewage			1.17	3.50	7.00	24.55

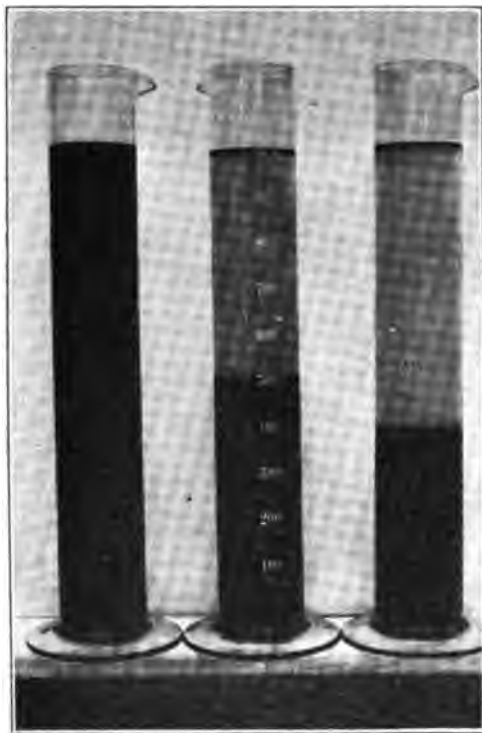


Fig. 9. Brooklyn, N. Y. Settlement of activated sludge: 1. At removal from activating tank. 2. Settlement in five minutes. 3. Settlement in twenty minutes.

It will be observed that a very good effluent was obtained on the fill-and-draw method of operation after 5 hrs.' aeration with 7 volumes of air per volume of sewage. This may be compared with the work of the tank aerator in 1914 under the continuous-flow method without retaining the activated sludge, with 9 volumes of air and 24 hrs.' retention; and also with 18 volumes of air in the same period.

The following extract by Mr. William T. Carpenter, our Chief Chemist, from our laboratory record is of interest:

The rapidity with which the organisms present reduce the demand for oxygen is noteworthy. During the process of refilling, the demand falls from about 200 parts per million on the average to about 60 parts per million. Part of this drop is, of course, due

to dilution with purified liquid from the previous run which remains with the sludge in the part of the tank below the draw-off pipe. Dilution, however, would reduce the demand only to $10/16$ of its original value, or to 123 parts per million. This demand of 63 parts (123-60) is satisfied by the nitrite and nitrate oxygen, which is also reduced much more than the dilution would account for, in addition to the atmospheric oxygen dissolved from the air blown thru the tank. This 63 parts is seen to be about seven complete saturations at summer temperature. Bartow and Mohlman call attention to the effect of nitrite and nitrate oxygen from the previous cycle in aiding the stability of sewage in the early stages of treatment.

The rate of fall of demand constantly diminishes thruout the cycle, thus conforming to what seems to be a general law of all purification processes, namely, that the action proceeds most rapidly at the start. This seems to indicate that there is proportionally a large volume of the less resistant matter present, which having high avidity for oxygen is attacked promptly, and that as the process continues the more resistant matter becomes a large proportion of the whole. It may indicate that a given amount of air would be most advantageously utilized by blowing it very rapidly at the beginning and less rapidly as the treatment proceeds.

A drop in efficiency is noticeable during August in all points under observation. This is very possibly due to accumulations of sludge in the bottom of the tank which are not lifted by the air and consequently interfere with nitrification. The presence of the deflectors makes direct observation of this point impossible without interruption of the experiment, but indirect evidence supports this theory.

Experiments were also successfully made with a continuous-flow activated-sludge aerator tank, but these have not yet been fully completed, and further work is being done this summer. In economy of operation the results so far obtained are fully equal to those obtained by the fill-and-draw method.

Our work during the present summer has been with the object of trying to remove the sludge not required for returning to the aerating tank, and continue to treat it with air in order to reduce and separate water from it. A series of tanks appears to be necessary for this purpose, and it seems possible by this means to concentrate it, and, if air enough is applied, even to render it so far stable that at least the volume is reduced and it will stand up a much longer period. It will probably contain a larger proportion



Fig. 10. Brooklyn, N. Y. Samples from continuous-flow process. 1. Crude sewage. 2. Contents of activating tank. 3. Sample similar to No. 2, settled ten minutes. 4. Sample of effluent from continuous-flow plant.

of nitrates, but we have had so many accidents and delays in getting under way with this work that nothing definite can be said about it as yet, and another year's work will be necessary. We are also trying to improve the stability of a rapidly clarified activated effluent by means of an aerated contact filter, thru which it is hoped that a high grade effluent can be obtained rapidly on the continuous method. Of this it is also too early to say anything definite.

The cost of aeration with us is high, far too high to enable the activated sludge method to compare favorably with the sprinkling filter, and while the effluent from the former is clearer and more sparkling, with us it has not been quite equal in stability on the average to the sprinkling filter effluent. Indeed, our sewage seems especially adapted to treatment on sprinkling filters, first being prepared by Imhoff tanks or fine screens, which latter we have been experimenting with as a preliminary measure previous to the sprinkling filter used in place of tanks.

We have been using the screens also in preparing the sewage for activation, but find that our coarsest screen is too fine for the best result. This screen (a Riensch-Wurl) has apertures of $5/64$ inch. Probably $1/8$ inch would be fine enough, and $1/4$ inch might be better, to precede activation.



Fig. 11. Milwaukee, Wis. Main outfall sewer at Jones Island. Flume at left supplies the activated sludge plant with sewage.

MILWAUKEE, WIS.

Of the various plants which are employing the activated sludge method, the plant at Milwaukee, Wis., is perhaps the most interesting as it is also the most extensive. The writer visited it March 20th of the present year in company with Mr. E. J. Fort, of Brooklyn, and Mr. C. E. Gregory, of Manhattan.



Fig. 12. Milwaukee, Wis. Experimental sewage treatment plant, Jones Island. The large tank at the left in use for activated sludge work.

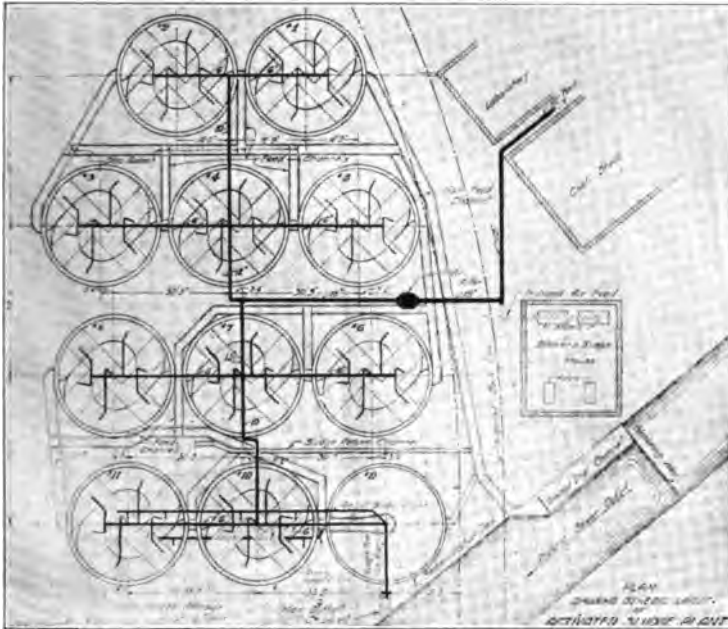


Fig. 13. Activated sludge plant at Milwaukee, Wis., situated on Jones Island.

At the time of our visit the plant was not doing its work as well as it has since. It had, in fact, only been in operation about two months, and as a consequence had not yet got the swing, or habit, of doing its best. I will not, however, go into the difficulties then experienced, as Mr. Hatton has himself done this better. We were enabled to see experiments in sludge de-watering with the Worthington press, which we did not then think very successful.

Milwaukee is so situated, and the cost of electric power is so low, that the activated sludge method seems particularly well adapted for its use in sewage treatment. For full success with the method at this place, problems of design appear the principal problems, especially if the sludge disposal problem has been solved.

A complete description of this plant has been published, and the last annual Report of the Sewerage Commission gives it in detail, with all the data concerning the operation of the same. A recent letter from Mr. T. Chalkley Hatton gives the following particulars



Fig. 14. Milwaukee, Wis. View of tank No. 2, in the foreground. No. 1 is seen beyond it, and the laboratory and experiment plant.

for use in this paper, to bring our information up to the present date:

This plant was designed to treat 1,620,000 gallons of raw, coarse-screened sewage with a four-hour aerating period, and 25 per cent of activated sludge retained in the aerating tanks, and produce an



Fig. 15. View of tank No. 1 showing surface of aerated sewage, pipe connections, etc. The plant was so designed that in case activated sludge did not prove a successful method of treatment, the tanks could be completed as Imhoff tanks after the removal of aeration apparatus, etc. The rods for extending the walls are therefore put in and left as shown.



Fig. 16. Milwaukee, Wis. Tanks 6, 7, 8, 9, 10, 11. The enlargement in the pipe in the foreground is the air filter.

effluent showing a removal of at least 95 per cent. of suspended matters and bacteria, with a dissolved oxygen content of five parts per million.

Owing to the design of the sedimentation basin we have not been able to treat more than 1,400,000 gallons thru the plant, and, in fact, 1,200,000 gallons is the limit from which we can get a satisfactory effluent. We provide for a 27-minute sedimentation with 1,620,000 gallons flowing thru. Our observations to date lead us to the belief that one hour's sedimentation period would be nearer correct.

We believe that our aerating capacity is sufficient to treat the full amount designed for, but owing to the small porosity of the plates, which runs from 1.85 to 4.50 cubic feet of air per minute per square foot of surface under 2 inches of water pressure; and the failure of the air filter to intercept all of the dust and oils, the diffusion of air thruout the aerating tanks is not as uniform as we would like it; this results in the deposition of sludge upon some of the plates and the uneconomical use of the air, and the building up of the pressure.

From our experience here we believe that we can practically overcome these difficulties in the design of the air filter; in changing the design of the bottom of our tanks; placing our air diffusers closer together and increasing their porosity; and particularly by intercepting the mineral matter, which now reaches the plant in great quantities, by well designed grit chambers.

The effect of cold weather upon the operation of the process is



Fig. 17. Milwaukee, Wis. Tanks 1, 2, 3, 4, 5. A part of the air filter is shown at the lower left hand corner.

to increase the amount of air necessary and to decrease the nitrates in the effluent, but during February, March and April we secured an average of 98 per cent removal of suspended matter, 95 per cent removal of bacteria, 3 to 5 parts of dissolved oxygen, no nitrates, a stability of 108 hours without dilution, and a very clear effluent in spite of the fact that the temperature of the raw sewage varied from 34° F. to 49° F., and the outside temperature from 14° F. below zero to 40° F. above.

After quite an elaborate experiment on the de-watering and drying of sludge, we find that there is very little problem connected therewith that has not already been solved in industrial establishments where materials of like character must be treated. There is no difficulty in either one of two kinds of presses (the Berrigan Press or the Simplex) of reducing the moisture from 99 per cent to 75 per cent; and there is no difficulty by either the direct or indirect dryer to reduce this moisture from 75 per cent to 10 per cent or lower.

We have performed this operation several times with success, and are now engaged in figuring out as closely as possible the cost of these two operations.

As to the value of the sludge for fertilizer, we have been pressing it and analyzing it now for three months, and we find that in our sludge in Milwaukee we average 5 per cent of available ammoniacal nitrogen, which is worth in the normal conditions \$2.50 per unit, or \$12.50 per ton of dry material. This does not take into consideration the available phosphoric acid or potash contained



Fig. 18. Tank 9, Milwaukee, Wis., equipped as settling tank. A flume is provided to take the separated sludge from the air lift in the center of this tank as shown. The clear effluent of the plant discharges from this tank into the lake.

in the sludge, which varies greatly in content, but averages a value of from \$1.00 to \$2.00.

In determining the values of our sludge as a fertilizer we have, however, paid no attention whatever to the value of phosphoric acid or potash, but we feel warranted in believing that this value will meet the cost of transportation of the sludge to the fertilizer market, which in our case is about \$1.05 per ton, assuming all of our market to be on the Atlantic Coast, which is after all the greatest market in the United States for low grade fertilizer.

The work at Milwaukee is now in its second year, and the plant now operating on a working scale, denominated the "permanent" activated sludge plant, has been in almost continuous service since January 22, 1916. Up to this date the plant was in partial operation for a short period for the purpose of building up sufficient activated sludge to warrant starting the continuous flow.

When operating with 25 per cent of sludge in the aerating tanks, and with a 4-hour running-thru period the designed capacity is 1,620,000 gal. per day, with a sedimentation period of 27 minutes, and the velocity of the liquor thru the eight aerating tanks over the 912 ft. of direct travel is 3.8 ft. per minute.

Compressed air is furnished by a motor-driven Connersville positive blower, having a capacity of 2,400 cu. ft. of free air per minute



Fig. 19. Effluent of the plant discharging into the lake. The rule thrust into the outflowing effluent is clearly visible thru it. The effluent is clear and sparkling.

compressed to 5 lbs. There are two complete blower units, which, including the blower house, cost \$2,986.69 erected.

The electric current is obtained from a hydro-electric development near the city and costs only 0.6 cent per kw.-hr. The volume and rate of air supplied to the whole plant and to the sludge tanks is measured by General Electric indicating recording integrating meters, costing \$314.25 and \$305.25, respectively. The contract price for building the eleven tanks with pile foundations and piping complete was \$55,000.00.

CHICAGO, ILL., THE PLANT OF ARMOUR & COMPANY.

The sewage is very concentrated, and varies widely in its composition, as may be judged from the following partial list of the various manufacturing departments where it originates; beef slaughtering, sheep slaughtering, rendering, cold storage, stick plant, fertilizer works, de-greasing plant, wool house, soda-fountain supplies factory, hog killing, pork curing, canned meats, power plant, and the ordinary sewage of 10,000 employees.

The minimum analysis showed 58 parts per million of suspended solids and the maximum, 2,760. Taking the average of all analysis made by the Sanitary District, for each of the three Armour sewers, and records regarding the amount of flow thru each, the result gives an average of 700 parts per million of suspended matters, day and night flow being included in the average.

This sewage, which originates from so many different sources and which contains so much solid material, is necessarily a difficult sewage to treat successfully. Experimental work has been under way for a considerable period with the object of finding the best method of treating this sewage.

The plant with which the activated sludge method is being studied has a capacity of 30,000 gallons. It is 20 ft. long, by 10 ft. deep, and 10 ft. wide, and divided by a central partition lengthwise of the tank, with an underflow at one end. The sewage enters at one end of the tank, flows the full length, and returns on the other side of the partition and is discharged over a weir into the settling tank, which is 6 ft. by 6 ft. in plan and 17 ft. in depth to the deepest part of the hopper bottom. An air lift is provided to return the settled sludge to the incoming sewage, or to carry the surplus of this to a sludge tank. Underflow and overflow baffles are placed in the aerating tank six feet apart, and are so adjusted that the sewage must take a zig-zag course in addition to flowing up and down.

Manufactured porous plates were first used for distributing the air, being placed in a saw-tooth-shaped false bottom, but they proved of uneven porosity and gave very poor distribution. They were abandoned very soon, and 1-inch galvanized iron pipe, perforated with 1/25 inch holes, two inches apart and staggered, was used in-



Fig. 20. The experimental plant of Armour and Company, Union Stock Yards, Chicago, Ill. The settling tank is seen in the foreground.

stead. The saw-tooth bottom was also removed, as it was found unnecessary. The pipe distributors give a very good distribution of air, and have the advantage that they can be taken up and cleaned without shutting down the system.

At the time of our visit in March the amount of air used was three cubic feet per gallon of sewage treated, and the cost was said to be about \$9.00 per million gallons treated for air alone.

The sludge was said to average about 25,000 gallons per million gallons of sewage, and to be 99 per cent water. When de-watered to 10 per cent. moisture, about $1\frac{1}{4}$ tons of dried material was obtained, carrying 5 to 12 per cent of fats.

Its principal constituents were as follows:

Ammonia	5.57	per cent.
Fat	5.54	per cent.
Bone phosphate of lime.....	4.50	per cent.
Total phosphoric acid.....	2.05	per cent.
Water-soluble potash.....	0.43	per cent.

For de-watering, small experimental machines, filter presses, centrifuges and driers have been tried, but nothing definite has resulted as yet.

The following data were received at the time of this writing (Aug. 22) from Mr. Guy L. Noble for use in this paper, to complete our record of this very interesting plant. He says:

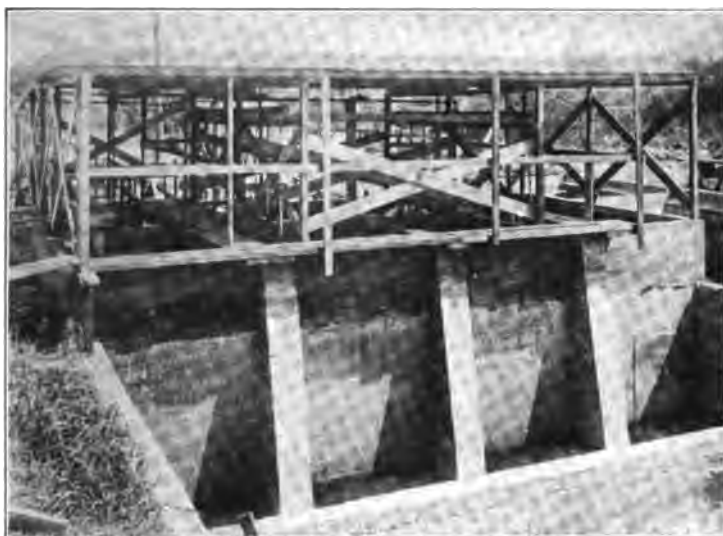


Fig. 21. Activated sludge plant of Armour and Company, at Fort Worth, Texas. The tanks are covered by a roof which made it impossible to show the surface of the sewage.

We have been operating our plant continuously ever since last February, and feel more surely than ever that activated sludge will probably be the cheapest and most efficient method of sewage disposal for our particular needs. We have been clarifying our water with a period of about 8-hour aeration. We are still experimenting with methods of de-watering the sludge. Our conclusions are not final, but at the present time it seems that a battery of vertical-flow settling tanks, which decreases moisture to 97 per cent, followed by a Worthington press, as used in Milwaukee, is the best method that we know of at the present time.

We are also attempting, by experimental work, to decrease the period of aeration by introducing pure cultures of organisms from active sludge, which appear to be especially active in producing nitrification. Our work, however, along this line is only in its infancy and we have no data to report. It may be of interest to you to know that we are installing an experimental plant at Ft. Worth, Texas, to determine the best methods to use on our sewage down there. We have found that the action of the organisms is inhibited by sewage warmer than about 95 degrees F. Our further analysis of the sludge for fertilizing value shows it will run between $4\frac{1}{2}$ and 5 units of ammonia, the value of it being, therefore, about what we have previously estimated—namely, \$9.00 or \$10.00 per ton in the dried state.

I am sorry that we are unable to give you any further information. We hope to have much more data regarding it after we build our first plant.

CHICAGO, ILL., PLANT OF THE SANITARY DISTRICT.

We visited this plant in March. It was installed for experimental work with activated sludge by the Sanitary District of Chicago, and was completed in January of the present year. At the time of our visit it was operating with twelve hours' retention, and five cubic feet of air per volume of sewage. As this plant is in the stock-yard district, the sewage treated is very similar to that described as being treated at the Armour plant.



Fig. 22. Sanitary District of Chicago sewage experiment plant at Union Stock Yards. View from the creek.

The plant consists mainly of four tanks for use in series or singly, each 23 ft. long and 6 ft. wide, by 12 ft. deep, the effective depth being 11.5 ft. Each tank is provided with 22 filtros plate air distributors, and has separate provision for measuring the air used.

The sedimentation tank is circular, 12 ft. in diameter and 12.5 ft. deep.

Sewage is pumped to the entrance of the first tank, where the activated sludge is mixed with it, the surplus sludge being kept stored and aerated until needed. At the time of our visit the regular cycle of work had not yet been established.



Fig. 23. Sanitary District of Chicago experiment plant. Aerating tanks for reactivating stored sludge.

Mr. Langdon Pearse, in charge of this plant, in a recent contribution to a general discussion of the problems of the aerated sludge process, (*Engineering News*, July 20, 1916, Page 109) made the following statement of his experience:

My personal experience with small experimental units was satisfactory, but in the plant put into operation by us in January, comprising four units, with a capacity of 35,000 gal. per day in a 24-hr.



Fig. 24. Sanitary district of Chicago. Activated sludge plant seen from the yard. There are four rectangular tanks connected, as shown, by the pipes at the right hand side of the picture. The air supply pipes are shown above the top of the tanks.



Fig. 25. Chicago, Ill. View of the activating tanks from above, showing surface of aerated sewage.

period, we have had considerable difficulty with the clogging of the plates. This apparently has been caused by the sewage, which contains a good deal of paunch manure, straw, hair and other material that will mat and clog. A recent examination of one tank with a nominal inside dimension of plan of 6x23 ft., with a single row of filtros plates down the center, indicates that all the plates have been broken. The breaks are apparently due to downward pressure. The plates were supported on two sides only, in wooden boxes, lined with galvanized iron, and were set in jointite. The use of wood probably caused the trouble, a more rigid frame being desirable. The distribution in the tank was seriously interfered with, a considerable deposit of hair and coarse sludge being found underneath the plates, many of which were badly shattered. We are endeavoring to find the exact reason for this difficulty, although it appears to be due to clogging and the loading of the water on top. No provision was made for back-flushing by water. For various reasons the air pressure has been shut off from time to time. The air distribution has been remodeled, the boxes being stiffened, and an additional support placed so that all plates are supported on four sides. This has proved satisfactory.

The air at our testing station is furnished by a rotary blower of the Connersville type, working against a 6-lb. head, the depth of water being 10½ ft. over the plates. We have a muslin screen on the intake of the blower. So far as we can ascertain, there has been no difficulty on the underside of the plates from any oily deposits, there being no trace of oil in the air boxes underneath.

In order to cure certain difficulties in measuring the air with



Fig. 26. Chicago, Ill. View of top of tanks showing pump and motor house, and air supply pipes, also Venturi meters (in the highest pipes shown) for measuring the air used.

a Venturi meter, a steel storage tank 5 ft. diameter, 5 ft. high, has been installed. This reduces the pulsating effect and forms a trap for oil or moisture.

Before our experiments are concluded I hope to run comparative tests on two tanks with perforated pipes and two tanks with filtros plates. I believe that considerable thought is still required to determine the proper design for the air-distribution system in order to make it satisfactory at a minimum cost.

I believe that *Engineering News* will do well to impress upon its readers the importance of going slow in the adoption of activated-sludge plants without thoro consideration of all the elements involved, as I think most of us still agree that it is not a simple process to operate, but one whose entire limitations are not yet developed.



Fig. 27. Chicago, Ill. View of top of tanks, showing surface of aerated sewage in tank, etc.

The cost problem is still in the air, particularly the cost of handling the sludge. Another warning should also be issued on the short-time tests lasting only two or three weeks, which are liable to give misleading results, as it takes several months in general to determine the efficiency and limitations of sewage-treatment methods definitely. We have noticed in our work that good results are obtained for the first three or four weeks, and then difficulties begin to develop that were not anticipated.

CLEVELAND, O.

The principal object of the activated sludge experiments at Cleveland is to investigate the practicability of obtaining a rapid clarification of the sewage, of effecting, if possible, a decoloration of the flow, which, owing to the presence of iron salts, has at times a yellow color that is imparted to the waters of the lake, sometimes, over a considerable area near the outlet of the sewer. At times this colored water is carried by wind currents to near-by bathing beaches, giving rise to objectionable conditions and public disapproval. It is hoped that the aeration method will remove this color from the sewage.

The plant is located on the lake shore near the existing experimental sewage disposal plant. The laboratory and mechanical installation of the latter are therefore available for this experiment.

Our visit on March 22, of the present year, was made under circumstances that were rather unfavorable. It had snowed all day and was still snowing when we reached the plant; but while we were there the snowing ceased. The temperature was below freezing.

The plant was completed in January of this year, and put into service collecting activated sludge in cold weather, which it did successfully in sufficient amount to operate on the continuous flow method within two weeks of starting.

The plant was designed to treat 1,000,000 gal. of sewage in 24 hours, with an aeration period of 4 hours, of which 2 hours would be expended on the sewage in the aeration tanks and 2 hours on the settled-out activated sludge in a re-aerating tank, previously to its being returned to the sewage aerating tank, where it is dis-

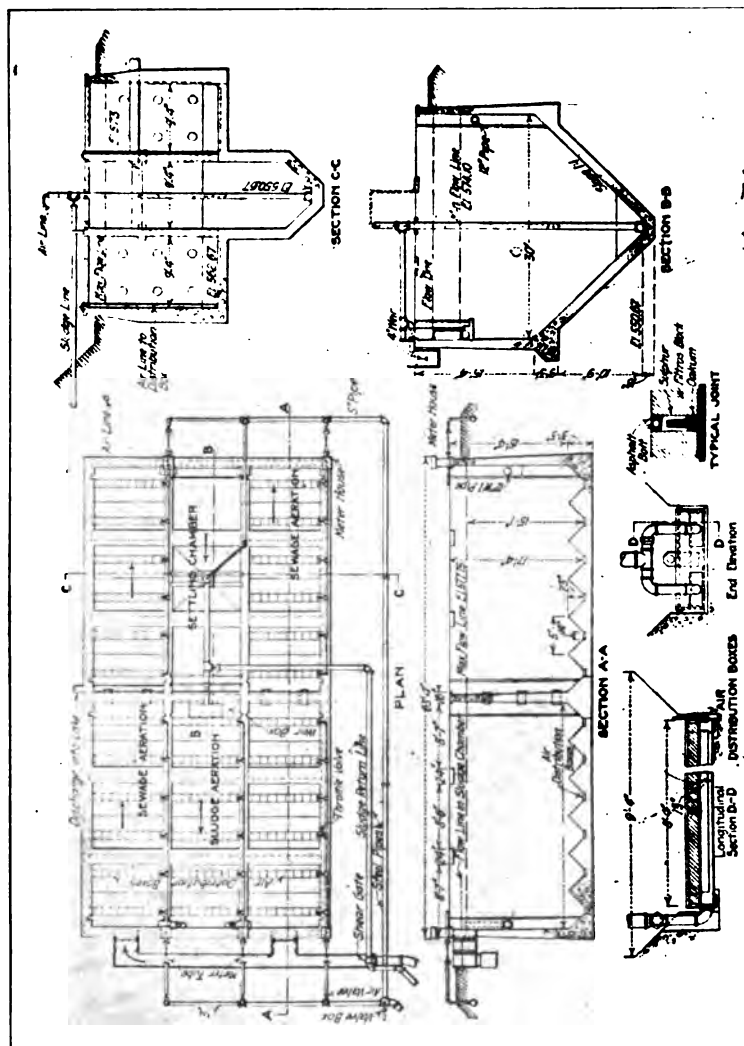




Fig. 29. Cleveland, Ohio. Activated sludge plant operating in winter. In the background Lake Erie is seen covered with ice to the horizon.

charged into the incoming sewage. The settling period at this rate is half hour.

The plant is a battery of tanks constructed as a unit about 60 ft. in length from east to west and 30 ft. in width. The plant is divided lengthwise by two walls into three equal divisions and this is subdivided by a cross wall, thus forming six chambers or tanks, each $9\frac{1}{2}$ ft. by 30 ft. in plan, five of which are 15 ft. in effective depth with their bottoms formed into valleys crossing the long dimensions of the chambers, in the lower part of which filtros plates are placed for supplying compressed air, occupying $\frac{1}{4}$ of the bottom area; each tank being independently provided with meters for measuring the air. The remaining tank, while of the same dimensions in plan as the others, as it is



Fig. 30. Cleveland, Ohio. General view of the plant. Cold weather did not interfere to any important extent with the operation of the plant.



Fig. 31. Cleveland, Ohio. View of plant showing sludge-air-lift pipes. Looking across center of plant towards the lake.

intended for sedimentation of the activated sewage, is provided with a hopper bottom. Its effective depth to the lowest point of the hopper is 27 ft. It is provided at its westerly end with a weir for the removal of the clear effluent, which is discharged into the lake. The settled sludge is removed from the bottom of the tank by means of an air-lift, which discharges it into the re-aerating tank, in which it is re-activated and from which it flows by gravity into the incoming sewage in the tanks at either side, a higher head being carried in the re-aeration tank than in the other tanks.

In operating the plant at the rate of 1,000,000 gal. per day the sewage enters from the supply pipe into the first aerating tanks,



Fig. 32. Cleveland, O. Surface of re-activating tank.



Fig. 33. Cleveland, O. View of the settling tank; looking longitudinally from east to west along top of plant.

in which it is agitated with 20 per cent to 25 per cent of its volume of activated sludge from the re-aerating tank. After one hour aeration it passes thru circular apertures in the dividing wall into the second aerating tank, where it receives a further aeration of one hour, and from this passes into the settling tank, thru which it is one-half an hour in passing; thence the effluent flows over a weir into the lake. The sludge is raised from the bottom of the settling tank into the re-aerating tank and, up to a predetermined quantity and as stated above, flows from this by gravity into the tank receiving the incoming sewage. The surplus sludge is removed from the settling tank by a by-pass pipe taken off from the discharge side of the air lift.

The compressed air is supplied by an electric motor-driven hydro-turbine, the pressure used at our visit being $9\frac{1}{2}$ pounds.

The design of the plant is very ingenious, and seemed to enable the operator of the plant to control the proportions of air and sewage and the handling of sludge with great facility thru a wide range of variation. The inlets and outlets are so arranged that long or short retention periods can very readily be studied. Flow thru the plant with tank aeration for as short a period as 30 minutes is provided for should this prove desirable.

As observed at the time of our visit, we were informed that the plant was operating at the rate of 400,000 gallons in 24 hours.



Fig. 34. Cleveland, O. The west or entrance end of the plant showing air pipes entering, etc.

The sewage averages 250 p. p. m. suspended solids, and the activated sludge recovered approximates 30 cu. yd., carrying 98 per cent. moisture, per million gallons.

The recovery averages about 55 per cent of the suspended solids. About 20 per cent of the sludge settles out in twenty minutes.

The temperature of the sewage entering the plant was 54° F. and the loss of heat in passing thru is about 1° C. The effluent remains stable 1½ days, equal to about 30 per cent on the stability scale.

ILLINOIS STATE WATER SURVEY ACTIVATED SLUDGE PLANT, CHAMPAIGN, ILL.

The writer is enabled thru the courtesy of Prof. Edward Bartow, Director, and Mr. J. F. Schnellbach, Assistant Engineer, State Water Survey, University of Illinois, to present the description of the plant at Champaign, which follows. It should be recalled in this connection that Prof. Bartow made some of the earliest studies of the activated sludge method, in November, 1914, and that his experimental work has been of the highest importance.

The Illinois State Water Survey has been carrying on sewage treatment experiments by the activated sludge process since November, 1914. The first experiments were conducted in the laboratory in bottles. Later a tank 9 inches square and 4 feet deep, with two glass sides and a filtros plate in the bottom for air diffusion, was successfully operated. At the conclusion of the labora-

tory experiments a plant consisting of 4 concrete tanks, each 3 ft. sq. and 9 ft. deep, was built in which further experiments were carried on by the fill and draw plan.

The plant which is at present being successfully operated is shown in the accompanying sketch. Originally, it was a septic tank used to treat the sewage from the city of Champaign. The re-constructed plant was designed to treat 200,000 gallons of domestic sewage a day and consists of a screen chamber and pump pit, a grit chamber of two compartments, an aeration chamber, a settling chamber, a blower room and a laboratory. Other parts of the plant include a sludge-drying bed and a pond into which the effluent from the process is discharged. It is expected that in a short time sludge-drying apparatus will be installed.

The sewage is drawn from the main sewer of Champaign, an 18-inch vitrified tile, carrying about $1\frac{1}{2}$ million gallons of sewage a day. The plant is housed in a frame structure 18 by 45 feet in plan. In providing the suction pit and screen chamber use was made of a man-hole in the sewer main. In this chamber a weir was placed in the outlet in order to raise the sewage level and provide suction for sewage pumps, also a screen with vertical bars spaced with three-quarter inch openings for screening the sewage. From the screen chamber the sewage is pumped to a grit chamber. This is a wooden box of two compartments, each 1 foot wide and 34 feet long. The outlet end of the chamber may be equipped with an adjustable weir over which the sewage must flow and where the rate of sewage pumping is measured.

From the grit chamber the sewage flows into the aeration chamber. This is a rectangular concrete tank 17 by $36\frac{1}{2}$ feet in plan and $9\frac{1}{2}$ feet deep, with a capacity of 36,000 gallons. The chamber is divided longitudinally by three baffles, thus making four compartments and causing the sewage to travel a distance of 140 feet thru the tank. The bottom of each compartment is built with hopper sides and has a chamber $10\frac{1}{2}$ inches wide and 4 inches deep projecting below and extending lengthwise thru the tank. Along the upper edge of the channel T-bars have been imbedded in the concrete on which filtros plates are laid. The channel below the filtros plates is divided into sections so that each set of 6 plates is separated from all the others. A one-inch air pipe leads to each set of plates from a three-inch continuous air main. The one-inch pipes are equipped with valves for controlling the air.

The aeration tank is of such a size that in treating 144,000 gallons of sewage and sludge a day the sewage will be aerated during a period of 6 hours. With a 5-hour period 170,000 gallons may be treated a day and with a 4-hour period, 216,000 gallons. The

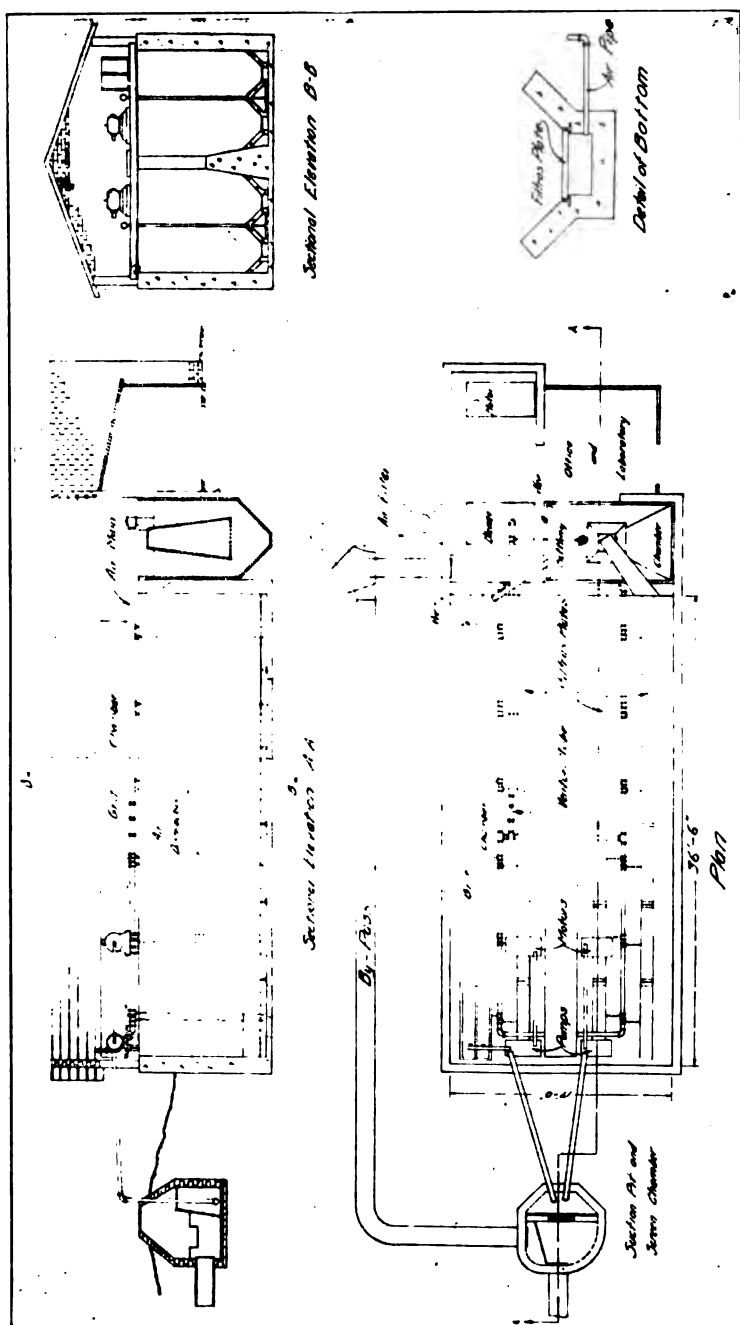


Fig. 35. Champaign, Ill. Activated sludge plant of the Illinois State Water Survey.

above rates will require the sewage to flow over the air-diffusion plates at the following approximate rates: 2.5 feet, 2.1 feet and 1.65 feet per minute respectively.

From the aeration chamber the treated sewage containing the activated sludge flows to the settling chamber. This is built of wood and has a hopper bottom. It is 6 by 10½ feet in plan and 10½ feet deep at the lowest point, and has a capacity of 3,700 gallons and a retention period of 23, 31 and 37 minutes, based on a 4, 5 and 6-hour period in the aeration chamber. In order to increase the settling of the sludge a hollow wooden pyramid has been placed in the settling chamber down thru which the liquor entering must pass. The pyramid is 15 in. square at the top and 3 ft. square at the bottom and extends to within 3½ feet of the bottom of the chamber. From the settling tank the purified sewage flows over a weir to the creek or into the pond.

The pond is a natural depression in the ground where at one time a small stream flowed, and in which dams have been placed to confine the effluent. It covers one-tenth of an acre and has a depth of water at its deepest point of about three feet.

The sludge bed has an area of about 256 square feet, and a depth of sand of about 8 inches.

The sewage is pumped from the suction chamber to the screen chamber by two centrifugal pumps, one with a capacity of 75 gallons per minute, and the other with a capacity of 110 gallons per minute. Each pump is belt-connected to a 3-h. p. electric motor.

For supplying air a rotary positive-pressure blower is provided. It has a capacity of 300 cubic feet a minute working under 6 pounds pressure. Connected with the blower suction there is an air filter consisting of a wire box covered with cheese cloth. Inserted in the air mains there is a Venturi meter. The blower is driven by a 15-h. p. electric motor.

The sludge is withdrawn from the settling chamber by an air lift, and can be discharged either into the raw sewage for seeding purposes or on to the sludge bed to be dried and later used as fertilizer. The sludge bed has not been a success.

The plant has now been in continuous operation for the past 7 weeks, prior to which time it has been operated intermittently for periods of from 1 to 3 weeks. The results obtained from treating the sewage by this method have been very gratifying, the dissolved oxygen determinations showing from 1 to 9 parts per million and stability test with methylene blue lasting from 5 to 15 days, after which time the samples have been discarded. The effluent is

clear, odorless, colorless, and sparkling, but at times contains small quantities of sludge.

Due to the insufficient capacity of the settling chamber it has been necessary to run the plant at considerably less than one-half the designed capacity, however, additional settling chambers are to be installed, after which it is hoped to operate at the normal rate.

The sewage has been treated with 1.5 to 3 cubic feet of air per gallon. Three cubic feet of air per gallon is more than the Champaign sewage requires but, due to the plant not being flexible enough, it is impossible to use less than three cubic feet at times. This difficulty will be overcome when the normal rate of operation is obtained.

The dried sludge has a nitrogen content of about 4.5 per cent.

THE LAWRENCE EXPERIMENT STATION OF THE MASSACHUSETTS STATE BOARD OF HEALTH.

The following data have been kindly supplied for the purposes of this paper by Mr. H. W. Clark, chemist and director, State Department of Health:

During the past three years the work at Lawrence has been continued both along the aerated slate tank method, and also by that known more commonly as the activated sludge process. More than a year ago, with five hours aeration in the Lawrence tank, it was possible with the use of 50,000 cubic feet of air per hour per million gallons of sewage treated, or $\frac{1}{4}$ cubic foot of air per gallon of sewage, to render the tank effluent stable during more than 70 per cent. of the time. Ten hours aeration with the same volume of air per hour per million gallons rendered the tank effluent stable 90 per cent. of the time. By five hours aeration, 80 per cent. of the suspended matters were collected and removed from the sewage, and by ten hours treatment, 90 per cent.

Five hours aeration removed the soluble organic nitrogen, including colloids, to the extent of 35 per cent. and this removal was increased to 60 per cent. by ten hours aeration. The albuminoid ammonia was reduced about 60 per cent. by five hours, and 80 per cent. by ten hours aeration.

The Lawrence aerating tank contains slabs of slate as colloiders. This has led some to the error of calling it a contact filter. In a contact filter at least 65 per cent. of the total space is filled with stone, while the slate colloiders only occupy about 5 per cent. of the space, having 95 per cent. free for sewage and air.

Another error sometimes made is that the Lawrence tank is intended only to prepare sewage for filtration, whereas, as early as 1912, an effluent was produced practically stable, and containing nitrates equal to 15 parts per million.

An interesting comparison is afforded by the operation of two aerated slate tanks containing sludge and growths, Nos. 449 and 449B, and two activated sludge tanks, so called, Nos. 465 and 482. These tanks hold only 110 to 200 gallons of sewage each.

From January 10 to March 29 (3-cycle period with one-hour sedimentation at the end of each period in tank No. 465), there were periods when a digestion of sludge occurred and the albuminoid ammonia in solution in the tank effluent averaged 66 per cent. greater than the albuminoid ammonia in solution in the sewage entering the tank and 12 per cent. greater than the total albuminoid ammonia in the sewage entering the tank. This phenomenon was at first a rather disquieting element in this investigation, but its causes were easily controlled.

The slate process, as exemplified by tanks 449 and 449B, gives considerably better purification in 10 hours, calculated upon removal of organic matter, than activated-sludge tank 465 in 3 hours and practically the same as tank 465 in 8 hours. By the slate tank method only 66 per cent. as much air is used in 10 hours as by the activated-sludge tank in 3 hours and only 37 per cent. as much as is used by the activated-sludge tank in 8 hours. Both methods give stable effluents, generally speaking, the slate-tank method requiring generally more time to accomplish this result but less air, and the effluent of the activated-sludge tank being the clearer in appearance. During the winter, as shown in the tables, the aerated slate tanks were operated at temperatures slightly greater than 40° F. and activated-sludge tanks were operated at different temperatures, that of tank 365 averaging 42° F. and of tank 482 averaging 55° F. Little difference in results was noted at first at these temperatures, but a period of digestion of sludge occurred during a portion of the winter in activated-sludge tank 465 and much organic matter went into solution. On the whole, except for this period of several weeks when the organic matter of the sewage in tank 465 was going into solution, the effluents from these two activated-sludge tanks operated at different temperatures were about equal, showing a general clearing of the effluent, and 80 per cent. of the samples stable. The work of the slate tanks during the winter period was much better, showing removals of 50 to 60 per cent. of the organic matter and practically every sample stable.

At Lawrence the sludge from both methods has lost the offensive characteristics of sewage sludge; it is more dense, that is, more easily drained, and more or less granular when dried. It is of greater

agricultural value, not only on account of the changes mentioned and increased nitrogenous contents, but also because a large percentage of the fatty matters present before treatment is destroyed.

The governing factors in the success of this process of sewage treatment, as I have stated in previous articles, are: (1) The cost of power for supplying the large volume of air necessary; (2) A sewage that readily yields itself to this method of treatment. It is not impossible to believe that certain sewages cannot be purified in this manner.

In conclusion, I wish to state that we cannot at Lawrence work out certain points in regard to such a method, these needing experiments upon a larger scale. It is probably true, however, that the method at first carried on by us at Lawrence, without the use of slate, is the more practical.

The following data regarding the experiments which resulted in the activated sludge process, at Lawrence, should be mentioned in this place.

In 1911, while making certain experiments at the station, it was noticed that the presence of certain growths in bottles of weak sewage aided the purification and caused it to occur in volume, that is, without the aid of filtering medium, as sand filters, or stone in sprinkling filters, etc. This purification in volume occurred in sealed bottles and with the liberation of oxygen. Following this discovery it was found that these growths, bacterial and algal, aided by forced aeration, effected a remarkable purification of sewage in a few hours. This was an absolutely new discovery in sewage purification. It is described in the report of the State Board of Health of Massachusetts for 1912, pages 344 and 345. See also pages 291, 292.

This investigating work was carried on in gallon bottles and carboys, and it was found that by 24 hours aeration of sewage containing biological growths of various kinds, an effluent could be obtained which was stable, containing at times nitrates equal to 15 parts per million, and with a removal of 70 per cent. of the organic matter. In this work the sewage was emptied from the bottles daily leaving only the growths and sewage slime to act together with aeration upon the fresh sewage placed daily in the bottles.

This work (writes Mr. H. W. Clark) was shown to Dr. Gilbert Fowler, of Manchester, England, at the time of his visit to the sta-

tion, on November 20, 1912. It was, in fact, the purification of sewage by what is now known as the activated sludge process, altho the name was not given to it at Lawrence but afterwards by Dr. Fowler himself.

On Fowler's return to England he and his colleagues, Edward Ardern and William T. Lockett, began similar work, and when the paper by these gentlemen was presented, a year and a half after his visit to Lawrence, Dr. Fowler acknowledged his debt to what he had seen at the station. He said during the discussion of the paper, it is only right to admit that the work was due to a visit to the experiment station at Lawrence, Mass., where he saw sewage which had been completely purified by 24 hours' aeration.

The Lawrence experimental work above described, and also work with the Lawrence form of tank, was summarized by Dr. McLean Wilson, of England, in an address at Manchester, as president of the Association of Sewage Works Managers, as follows:

Meanwhile many investigators had been trying the effect of continuous aeration of sewage, most of them having apparently in view the direct chemical oxidation of the organic matters; but in 1912 Messrs. Clark and Gage, of the Massachusetts State Board of Health, in experiments on the aeration of sewage in a tank containing slabs of slate, found that the slate became covered with a compact brown layer which separated out both the suspended solids and the colloidal matters of sewage.—(*The Surveyor, London, Eng., July 16, 1915.*)

During the past three years the work at Lawrence has been continued both along the aerated slate tank method and also by that method known more commonly now as the activated sludge process, both depending upon the purification of sewage by aeration and growths; the main results of which have been as stated above.

BALTIMORE, MD.

Our visit to the Baltimore activated-sludge plant was made early in the present year under the guidance of Mr. Leslie C. Frank, Sanitary Engineer, U. S. Public Health Service, and with the kind permission of Mr. Calvin W. Hendrick, Chief Engineer of the city of Baltimore.

The plant had been shut down in order that a new arrangement of the air distributors might be effected, and this gave the fortunate opportunity to get photos of the new apparatus, which closes not

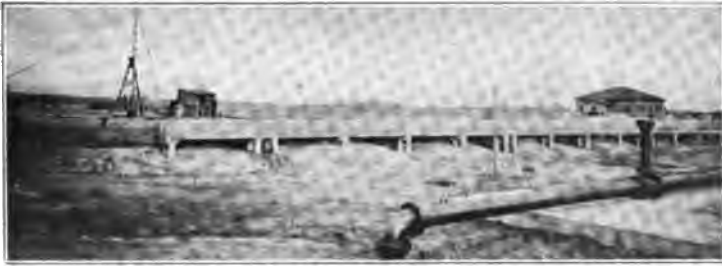


Fig. 36. Baltimore, Md. Activated sludge plant is shown at left hand.

unlike an umbrella, in order that it may be introduced into the tank thru the narrow opening at the top and is opened out to a horizontal position when in place in the tank. The tank itself was constructed as an Imhoff tank and as such had a capacity of 500,000 gallons per day. Operated by the activated sludge method its capacity is about 200,000 gallons per day. As it was not in operation, the only further remark that seems called for is that it seemed to give much promise of success but enough work had not been done to justify any positive statement.

It was stated by Mr. Frank that much difficulty had been experienced with oil getting into the filtros discs used as air distributors, and that this was not prevented by the use of a gravel filter thru which the compressed air passed before entering the tank. This was thought to be due to the type of air compressor used, which produced an oil vapor that passed along with the air, gradually forming a sludge on the cold under surface of the discs.

The form of tank and the method of operation used in the Baltimore activated sludge experiments may be described briefly as fol-



Fig. 37. Baltimore, Md. Outlet from activated sludge plant.
View over top of Imhoff tanks.



Fig. 38. Baltimore, Md. Near view of "Umbrella shape" grid with discs in place, for supplying compressed air to activated sludge tank.

lows: The tank is a converted Imhoff tank of the circular type. The central sludge chamber served as an oxidation chamber and the sedimentation chamber serves its original purpose. Sewage is introduced into the tank at the bottom thru the 8-inch sludge pipe, passes up thru the oxidation chamber and escapes by natural air lift thru the old gas vent into the settling chamber. The sludge settling out in this chamber returns thru the slot into the oxidation chamber and the settled supernatant liquid passes out over the circumferential weirs surrounding the settling chamber. Modifications have been made in this method of operation at various times but the above described method is typical.

The outstanding fact regarding the Baltimore activated sludge experiments is the fact that they have not thus far been successful in demonstrating the feasibility or economy of the process under the existing experimental conditions. It was realized soon after the experiments were begun that the passage of oil vapor from the

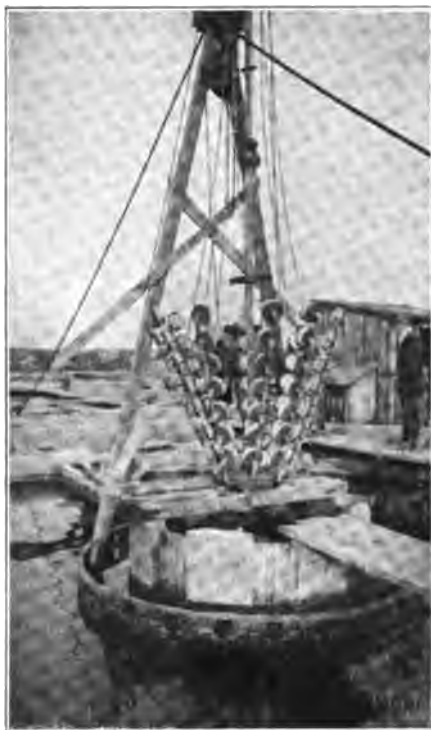


Fig. 39. Baltimore, Md. View of grid and top of tank, grid ready to lower thru the narrow neck of the top of tank. When at the bottom of the tank grid is opened like an umbrella, with its arms in a horizontal position.

internal-lubrication compressor to the inside of the diffuser system was not only disastrous but also seemingly impossible to prevent. Three different types of diffuser materials have been experimented with, namely, carborundum, 120 grit; brass discs perforated with $1/32$ -inch holes; and filtros, grade 5-R. In every case a mat of sludge formed on the bottom of the diffusers and the resulting high resistance either greatly increased the total air pressure necessary or else relieved itself by cracking one or more of the diffusers.

The experience at other experiment stations apparently indicates that no serious difficulty need be expected because of sludge accumulations on the under side of diffusers. All of these experiment stations, however, so far as known, use air blowers not requiring internal lubrication and the following explanation of the difficulties at Baltimore, therefore, seems fairly obvious. Probably every activated sludge tank is occasionally subject to "air-shut-down" periods for purposes of adjustment, etc., and during these periods the air

in the diffuser system is displaced by water from the interior of the tank plus such of the sludge particles as are sufficiently fine to pass thru the pores of the diffusers. Then, when the compressed air is again admitted the water is forced back thru the diffuser material and carries with it all of the sludge particles that are in as fine a state of subdivision as when they entered. If, however, permanent clumping of the sludge particles should take place on the inside of the diffuser system, the clumped sludge particles would then be too large to pass thru the diffuser pores and would tend to accumulate as a mat on the under surface of the diffusers. It seems logical to believe that when oil is present on the interior of the diffuser system it attracts and mixes with the fine sludge particles and forms coarser oily clumps which, *because of their oily nature*, are no longer capable of being dispersed or separated into the original degree of fineness, collecting instead on the under diffuser surface when the compressed air is again admitted. The apparent empirical proof of this lies in the fact that every time diffusers were removed from the Baltimore tank their under surfaces were heavily coated with a very oily-feeling sludge. The following laboratory test further strengthens this belief: Equal amounts of activated sludge were placed in two 250 c.c. bottles. Both of the bottles were then nearly filled with clear water and a few drops of oil introduced into one of them. Both bottles were then vigorously shaken. Immediately after stopping the shaking action practically all of the activated sludge particles in the "oily" bottle were seen to clump together and to rise rapidly to the surface of the liquid, forming a very definite layer there. The sludge particles in the other bottle, however, remained dispersed for a much longer period, finally settling very slowly to the bottom of the bottle, and the slightest agitation being capable of again dispersing them. Much more vigorous agitation of the "oily" bottle did not produce dispersion.

It was soon realized, also, that probably both the diffuser area and the air supply were inadequate. The ratio of diffuser surface to average oxidation chamber area was about 1:17. The blower could not be expected to compress more than 80 cubic feet of free air per minute to 10 pounds per square inch. The Milwaukee figure of 1.77 cubic feet of free air per gallon of sewage refers to tanks 10 feet deep. For a 20-ft. depth of air travel as at Baltimore this should be equivalent to 0.88 cubic foot per gallon, or, a sewage-air ratio of about 1:6.5. On this basis the above-mentioned capacity of the blower should be capable of purifying 0.205 cubic foot of sewage per second, if the 80 cubic feet of air were actually delivered to the tank and properly distributed. As a matter of fact, the above described clogging of diffusers resulted in such a high resistance thru them and constituted such a high load on the compressor that the amount of free air actually compressed probably rarely reached more than 15 or 20 cubic feet per minute, the rest being lost as slip-



Fig. 40. Baltimore, Md. Showing grid opened for trial at surface.

page back thru the compressor. This low actual air supply was confirmed by readings of the Venturi manometer. The fire which destroyed the compressor house abruptly terminated this work by destroying the manometer.

For very short periods after bringing the sludge to a good degree of activation, it was possible to operate the tank continuously with the above mentioned load of 0.2 cubic foot per second, securing a very clear-looking effluent. The period, however, was so short that it was impossible to make satisfactory observations upon it. The sludge always very quickly lost its activated condition.

The above experiences made it obviously desirable: (1) to secure an air supply which would not deliver oil to the diffuser system; (2) to enlarge the compressor equipment; (3) to increase the diffuser ratio. The funds available for those modifications were totally inadequate, but fortunately, the Connersville Blower Company offered to construct one of their positive blowers with a rated capacity of 195 cubic feet per minute, and the General Filtration Company offered to furnish sufficient additional filtros discs to increase the diffuser ratio to 1:8.6, this being the maximum ratio it seemed possible to obtain with the present form of umbrella-shaped grid and still retain the desirable ability of raising it from the tank. The Public Health Service furnished a 15-h.p. motor to drive the blower. This enlarging equipment has since been installed.

In addition to the above described increase in equipment, steps have also been taken to treat Imhoff tank effluent instead of raw sewage. In October, 1915, the idea suggested itself that some form of preliminary treatment might possibly be of advantage as pre-



Fig. 41. Baltimore, Md. Putting new "Filtros" discs in place on grid.

ceding the activated sludge method. The relation between the biologic oxygen demand of the influent sewage and the amount of compressed air necessary in the activated sludge method might, and even should, bear an almost arithmetical relation to each other. Imhoff tank treatment, exclusive of the cost of sludge drying, may be estimated to cost roughly \$1.00 per million gallons for the average municipality. In *Engineering and Contracting*, of October 27th, 1915, Mr. Hatton estimates the cost of air alone to be \$4.45 per million gallons of sewage, this being on a basis of \$2.50 per million cubic feet of air compressed. On this basis, and with the tentative assumption that it will not prove possible further to reduce the air cost, Imhoff tank treatment would be required to reduce the oxygen demand only 22.6 per cent. before it began to assume importance as a form of treatment preliminary to the activated sludge method. At the same time the amount of sludge produced by the activated sludge method ought thereby to be considerably reduced. It is certainly still questionable whether activated sludge can be as economically disposed of as Imhoff tank sludge. On January 4 of this year, dosing of the Baltimore activated sludge apparatus at the Hygienic Laboratory with Imhoff tank effluent began in order to make a rough comparison of the amount of sludge thus produced with the amount derived from raw sewage. The results are encouraging. Estimates indicate that instead of producing one volume of sludge for every 104 volumes of sewage treated, which was true of the unsettled sewage, there was produced only one volume of sludge for every 525 volumes of settled sewage. The sewage there is, of course, stronger than the average municipal sewage, having an average 24-hr., 20° C., oxygen demand of 177 p.p.m., and it is probable that a greater proportion of the oxygen demand

material is settleable, but nevertheless, the above figures are significant, so much so that the above-mentioned steps have been taken to treat Imhoff tank effluent instead of raw sewage in the Baltimore tank. (*Above quotation contributed by Mr. Leslie C. Frank, Aug. 26, 1916.*)

A new air compressor has recently been installed, being a Connersville blower with a capacity of 195 cubic feet of free air per minute, and additional diffusers have also been placed. The experimental work may thus be considered as having recently started anew.

The umbrella-shaped diffuser was lifted out of the tank early in the summer, and 60 new filtros discs clamped into place, thus doubling the diffuser area. The old discs were carefully washed and replaced. They showed evidences of disintegration, some being distinctly more crumbly than the new ones, and many of the old plates were cracked. This it was thought, might have been caused by the alkalinity of the sewage.

The old and new discs represented two widely separated shipments.

HOUSTON, TEXAS.

This was one of the early experimental installations on a large scale, and was put into operation in September, 1915.

Three tanks were constructed. The first was a continuous flow tank with a capacity of 10,400 gallons in the aerating compartment, and 3,300 gallons in the settling compartment.

During operation, variable quantities of air was supplied, and the rate of sewage flow was also varied. At a certain time each day a large quantity of night soil was emptied into the pump well pit, and the sewage pumped into the main leading to the filter bed contained a great excess of organic solids. By filling the aerating tank with this sewage it was possible rapidly to build up the activated sludge in the tank.

Operation began in September, 1915, and was continued until January, 1916. The usual amount of air used was 6,800 cubic feet of free air per hour.

When operation started, the tank was filled and aerated 24 hours, at which time signs of activation appeared; air was then shut off, and contents allowed to settle for thirty minutes; the clear liquid was then thrown off and the tank refilled with crude sewage and the air again turned on.

This 24-hour cycle was continued four days, after which for seven days drawing and filling was accomplished every four hours. At the end of the eleventh day from the beginning, the amount of sludge was found to be about 13 per cent.

On the twelfth day from the beginning, operation of the tank on the continuous flow plan was begun with a rate of 2,000 gallons per hour, with 6,800 cubic feet of air per hour. This rate was found too great and the sewage was reduced to 1,000 gallons per hour on the fifteenth day.

The rate was then gradually increased to 3,590 gallons per hour by the thirtieth day and operated at that rate for the remainder of the year. At the thirtieth day the sludge amounted to 24 per cent., and tests of the effluent showed it to have a relative stability of 95 per cent., and the oxygen consumed varied from 10 to 16 p.p.m.

Some defects were found in the tank as built. There was a tendency to short circuit, that is, masses would get thru the tank without complete aeration, in less time than the average detention period. The remedy for this was determined to be constructing a long and comparatively narrow tank. The air was not uniformly distributed over the surface of the tank, and it was observed that better results could be obtained and cost saved by a more uniform distribution of air.

It seemed evident that the aerators should be placed in rows crossing the tank rather than along the central axis, as thus every particle of the flow would have to pass over aerators, and the entire flow would be more uniform in rate thruout any cross-section of the tank.

The settling tank was unsatisfactory in two ways:

First, the side slopes were not steep enough, especially in the corners. Experiments made indicated that the slopes of an inverted pyramid should be at least 1.7 vertical to 1 horizontal. If the tank

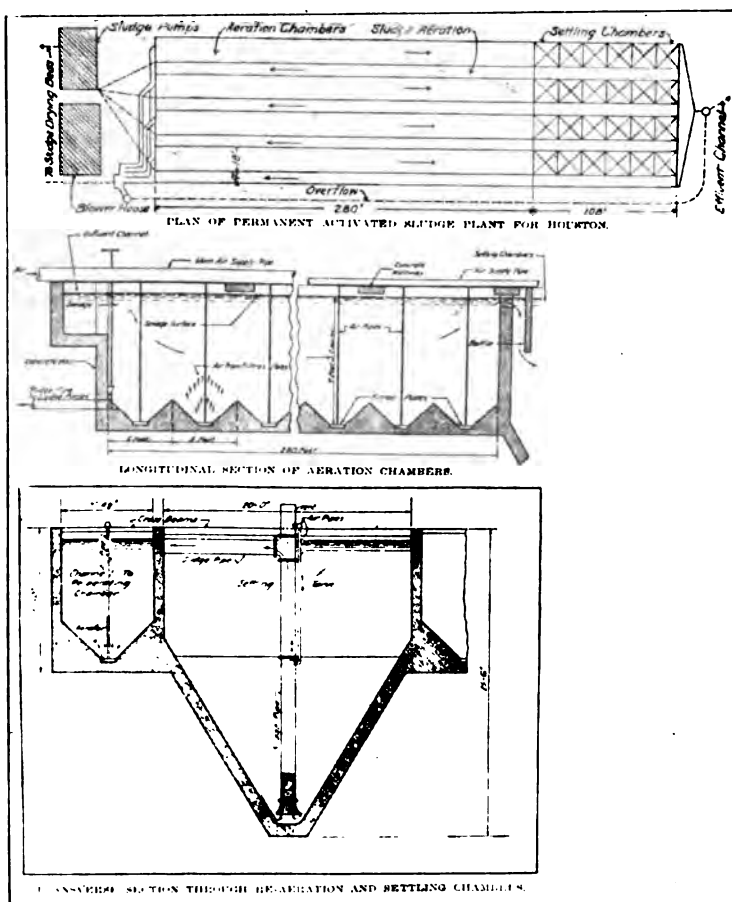
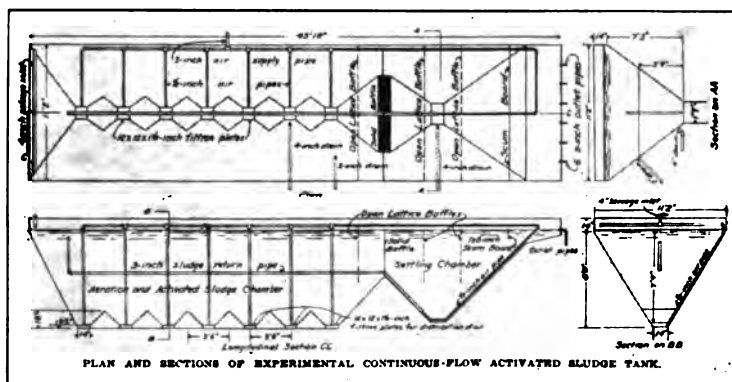


Fig. 42a and b. Houston, Tex. Plans of activated sludge plants.
(From *Municipal Journal*.)

were circular in plan with an inverted cone the slopes of the conical surface would not have to be greater than $1\frac{1}{2}$ vertical to 1 horizontal.

Second, this tank was unsatisfactory because there was a tendency for sludge which had partially settled to be stirred up by vertical currents at the outlet. This could have been prevented by making the outlet of the tank vertical for a few feet below the surface of the water, instead of inclined.

This tank was built with the intentions,

First, to demonstrate the feasibility of a continuous flow tank;

Second, to observe all defects in the design, so as to remedy these in the design for the permanent plant.

In spite of the defects, the tank demonstrated that a continuous flow tank is absolutely feasible and can give satisfactory results.

Two permanent plants are planned for the city service. The north side plant will consist at present of four units, each of capacity to provide for 37,100 persons, or an average flow of 2,190 gallons per minute.

The aerating detention period is planned to be 1 hour and 50 minutes. The aerating tanks will be provided with 0.26 cubic foot of free air per minute per square foot of tank surface. A sedimentation period of 40 minutes will be given. From the settling tanks the sludge will flow into the re-aerating tanks where the detention will be 3 hours. There will be three high-pressure blowers, each with a capacity of 3,750 cubic feet of air per minute under 5 pounds pressure. One blower will be a stand-by. The estimated cost of this plant complete is \$250,000.

The south side plant will be about one-half the capacity of the foregoing, and will cost about \$128,000.

Both plants are estimated to have a capacity of 2,480 million gallons per year. About 165 kw. of electric current will be used, and the annual disposal cost, including labor and supervision, is estimated to be \$26,670.

It is estimated that when 18,900,000 gallons of sewage per day is being treated the cost will be about \$9.14 per million gallons.

It is also estimated that treatment by Imhoff tanks and sprinkling filters would not cost less than \$11.00 per million gallons.

The excess sludge will be dried upon sludge beds, and it is believed that farmers and gardeners will be glad to remove it. Later it is hoped to install apparatus for drying the sludge, so that it can be sold.

The above data are mainly extracted from a recent paper which appeared in April of this year in the *Municipal Journal*, and from a report issued by the city engineer, Mr. E. E. Sands, early this year.

A recent letter from the city engineer of Houston states in regard to activated sludge:

We have discontinued any experimental work at Houston, and are now building our plant. This plant is a relatively small plant, and will only treat 18 million gallons per day.

This is rather a modest view to take. In fact, this new plant will probably be the largest in the country for some time after its completion, and will be of the greatest interest to all sanitary engineers.

SAN MARCOS, TEXAS.

This activated sludge plant, designed by Mr. Ashley F. Wilson, while not a large installation, is provided for regular service, and is doing its work. So far the writer has seen no mention of it in our technical papers.

As it is described by Mr. Wilson himself in the following letter sent to the writer for use as data in this paper, we give it as received:

We have had innumerable delays and as yet are not in position to say that our plant is entirely satisfactory, but with the changes we are making now, and expect to complete in about ten days, I think our plant will be entirely satisfactory.

The aerating tank is made of concrete and is 16 feet wide, 40 feet long and 10 feet from top of wall to top of filtros plates. It has three longitudinal baffle walls open at alternate ends so that the tank is practically a channel 4 feet wide, 10 feet deep and four times 40 feet, or 160 feet long, that is, the sewage flows for 160

feet thru the tank. There is a single row of filtros plates down the center of each compartment, with plates spaced 3 feet on centers. The plates are set each in the bottom of a hopper, making a kind of saw-toothed bottom. There are 52 filtros plates, I believe, in the tank. The plates are set in concrete recesses and cemented in place with ordinary cement mortar. The air supply to the under side of the plates is by means of a grill work of piping so that the plates are inter-connected. No orifice is used as it was thought that the plates themselves would regulate the supply sufficiently close. There is also a provision for draining the under side of the plates.

Our aerating chamber has been quite satisfactory, but I cannot say as much for our settling tank. In building this we did not give sufficient slope to the bottom, and as a result we are having to cut it out and will put in a new one. We are engaged in this work now and expect to have it complete in about ten days. When complete, our settling tank will be 10 feet wide, 20 feet long and about 20 feet at the deepest point, and the sides will have a slope of about one horizontal to two vertical. I believe that when we complete remodeling our settling tank there will be no further trouble in the operation of our plant.

We have been operating our tank with $7\frac{1}{2}$ to 8 feet of sewage over our filtros plates. Our air is supplied by a Connersville blower rated at 260 cubic feet per minute at 750 revolutions. We have been operating the blower at 5 pounds pressure and 600 revolutions. (I should have added that the above rating is on the basis of 5 pound pressure.) In operating at this speed and pressure we find that it requires 4 kw. of current to drive the motor.

Now as to our experience. Before placing our filtros plates we made a relative test of their capacity for passing air. We passed the air thru a $\frac{3}{8}$ -inch orifice and measured the difference in pressure by means of a U-tube. We so regulated our air supply as to maintain a pressure of 1-inch of water under the plates being tested. We found that it required a difference in pressure thru the orifice ranging from 24 to 48 inches of water to maintain the 1 inch of pressure under the various plates. When we first started operating the aerating tank we obtained a very uniform and satisfactory distribution of air, judging by the agitation at the surface, but later on some of the plates began to choke down and now there are two or three of them that have almost stopped. I might say that our air is passed thru a filter stuffed with excelsior before going to the plates. One of our plates gradually grew livelier than the others and finally became a small geyser, so we shut off the air and pumped out the tank and found the plate had developed a hole in one edge. This hole was evidently started from a crack in the filtros plate, and had gradually worn out until about an inch in diameter. We

cut this plate out and found it showed signs of softening. Another one of the plates is showing signs of the same trouble at present, but as yet we have not pumped down to look at it.

One trouble we have experienced that I have not seen mentioned elsewhere is the tendency of the sludge to rise to the top. If we shut off the air and let our liquor lie quiescent for as long as two hours the sludge will all rise to the top. This also applies to the settling tank, where the sludge lodges on the sides or elsewhere and fails to be caught by the return pump. This rising of the sludge is due to the formation of myriads of minute gas bubbles thruout the body of the sludge. As soon as sufficient bubbles have formed to reduce the specific gravity below that of the liquor, the sludge immediately goes to the top. This usually requires about two hours time.

We have been running about 150,000 gallons of sewage per day thru the plant, and have obtained an effluent clear and sparkling with a relative stability of 99 per cent. according to the methylene blue test of the American Public Health Association, and with a bacterial reduction of about 98 per cent. The plant is practically free from odor.

I have written the above off hand and rather hastily and if there are any points I have failed to cover, I will be very glad to write you further. I believe the activated sludge method is going to take a very prominent place in the purification of sewage in the future. I am very well satisfied with our plant, but if I were building another, I would, of course, expect to improve upon it.

EDMONTON, ALBERTA, CANADA.

The writer is informed by Mr. A. W. Haddow, acting city engineer of Edmonton, that this plant "was designed eighteen months ago, when very little was known about the activated sludge process, and as the plant was not solely for experimental purposes, we took the precaution of building an Imhoff tank alongside of the aerating tanks."

The following data are supplied by Mr. Haddow, about the Ross Flats Sewage Disposal Plant, under date of August 28, 1916:

System—Combined.

Area Contributing—294 acres.

Population—4,500.

Dry Weather Flow—33,600 cubic feet per day.

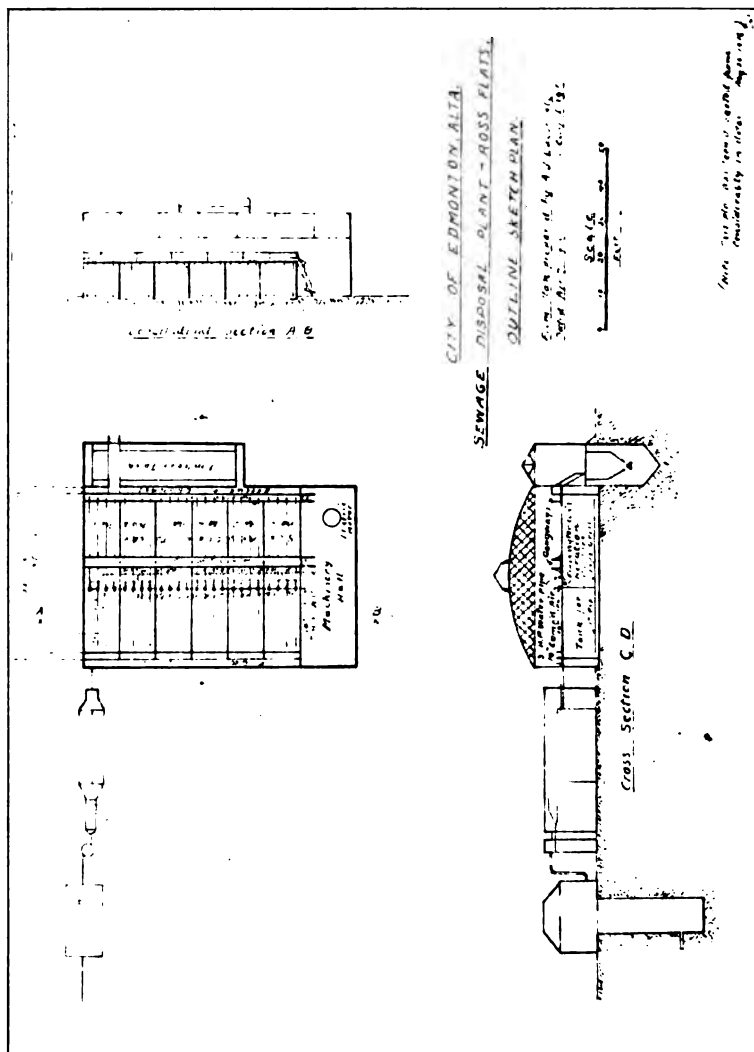


Fig. 43. Edmonton, Alberta. Sketch plan of activated sludge plant.



Fig. 44. Edmonton, Alberta. Views of the plant.

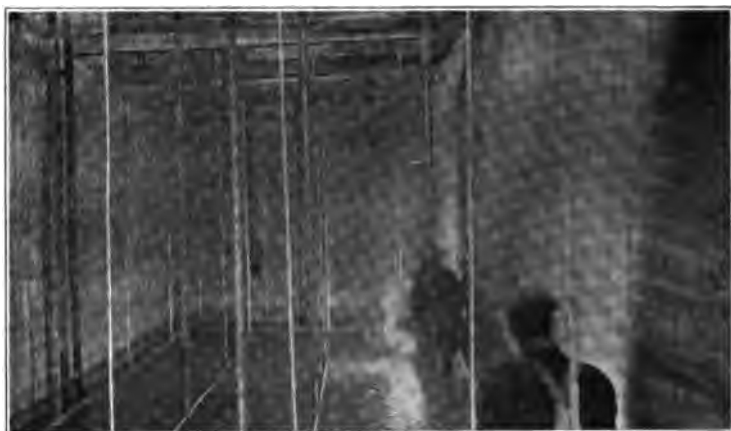


Fig. 45. Edmonton, Alberta. Activating tank, showing air supply grid.

Storm Flow—The maximum flow to be treated is 54,000 cubic feet per day, equal to 75 Imp. gallons per head of population. The balance will overflow into the North Saskatchewan River thru the present outlet.

Nature of Sewage—Non-septic, very little trade waste.

Pumping—All contributing sewage has to be pumped and enters the pump-well thru a cage for rough screening. This cage can be lifted to floor level of pump-house to be cleaned. There is no suction lift, and the maximum force lift from bottom of well to baffling chamber is 45 feet.

Pumps—One 4-inch single-stage, vertical spindle, centrifugal pump, electric driven, automatically controlled by a float. Capacity under trial 50 cu. ft. per minute, pumping against an average head of 42 ft. plus friction. One duplicate pump complete, ready for emergency service.

Motors—One 11-h.p. motor, direct connected to each pump. Power consumed, 4 kw. per hour equals 1 1/3 kw. hr. per 1,000 cu. ft. pumped.

Baffle Well—Small circular well, 4 ft. diameter, with baffle to break force of discharge from pumps to grit chamber.

Grit Chamber—Simple rough screening, and settling chamber in duplicate.

Aerating Chambers—Originally designed for live-earth beds; number, six. Fill and draw principle, but could easily be converted into continuous flow by a little construction work. Length 44 ft.,

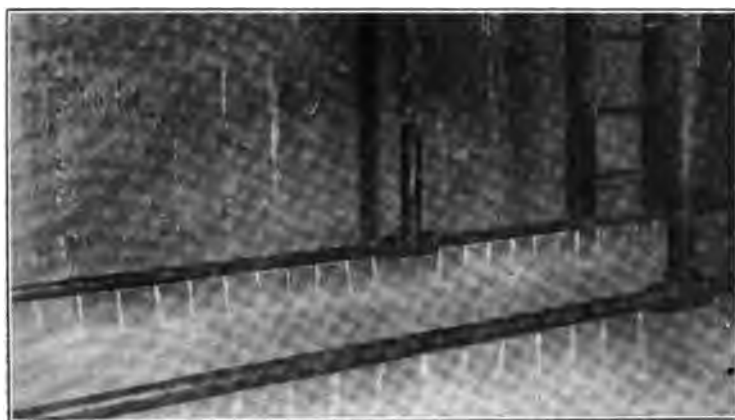


Fig. 46. Edmonton, Alberta. Showing flush water passing thru apertures in bottom of air supply grid.

width 10 ft. Total depth about 8 ft. Depth of sludge about 2 ft. Capacity of each 3,420 cu. ft. Working capacity above sludge 2,500 cu. ft.

Note— Only one tank in operation at present.

Imhoff Tank—Originally designed at suitable elevation to take effluent from what are now the aerating tanks. It is now being used for independent experiments, and takes part of the raw sewage direct from grit chamber. It could take effluent or sludge from aerating tanks, if such an experiment should ever be tried. The effluent at present goes direct to the river. Total depth 21 ft. Capacity of flowing-thru chamber 3,780 cu. ft. Capacity of digestion chamber 6,340 cu. ft.

Sterilization and Sludge Disposal—No provision made at present beyond reserving sites.

Air Plant and Air Distribution—One, size No. 31, Connorsville high-pressure blower. Capacity under trial against a working pressure of $3\frac{1}{2}$ pounds thru a 4-in. discharge: Low speed (255 r.p.m.) 180 cu. ft. of free air per minute; high speed (330 r.p.m.) 240 cu. ft. of free air per minute. The maximum may be increased later by altering the belt drive. The blower has capacity to spare for the one tank in operation, but a blower of a larger size will be ordered if all the tanks are fitted up for aeration, when the present blower will act as a spare. The air-main along the center of the tanks has been started off at 10-inch diameter in view of this. This 10-inch main is of cast iron, as we find it best for tapping and making tight connections for the down pipes. The tank under experiment has four



Fig. 47. Edmonton, Alberta. Showing connections at top of air pipes.

1½-inch down pipes, with a valve and a Dart union below the valve on each pipe. They are placed at 30-inch centers and branch into two 1-inch pipes at the bottom of the tank, one running towards each end, where they are plugged. Each down pipe with its two branches is an independent unit, and by unscrewing the Dart union, it can be lifted for examination without interfering with the blowing on the other three pipes. The two branches are supported from channel-irons by means of six ¾-inch hollow rods (pipe) which, by means of a thread and nut give a slow-motion control of the air pipe. We find that after the air pipes have been set dead level that we have both *to raise and to lower* them by means of this nut to obtain perfect air distribution. We cannot give any reason for this. The air pipes have ⅛-inch holes drilled on the under side at 3-inch centers. We find this gives better distribution than drilling on the top or on the sides. So far the resulting air distribution is excellent. However, no sludge is yet accumulated, but we have taken precautions to obviate trouble from this source. Each down-pipe is connected below the valve and above the Dart union to a branch from a 3-inch high-pressure water main (100 lbs. per sq. in.) for flushing purposes. These four water branches are controlled by a single valve. In addition, the water can be shut off by a main valve, and steam admitted thru the same piping. Provision is made for expansion on this account. Then, as already stated, each air-line can be lifted independently and cleaned if the water and steam are not sufficient. A check valve is introduced on the main air feed near the blower to prevent water getting into the blower in case of carelessness in operating the valves.

Motor—One 15-h.p. belt-connected, 220-volt a. c. 60-cycle, 3-phase motor. Consumption at low speed, 4 kw. per hour: con-

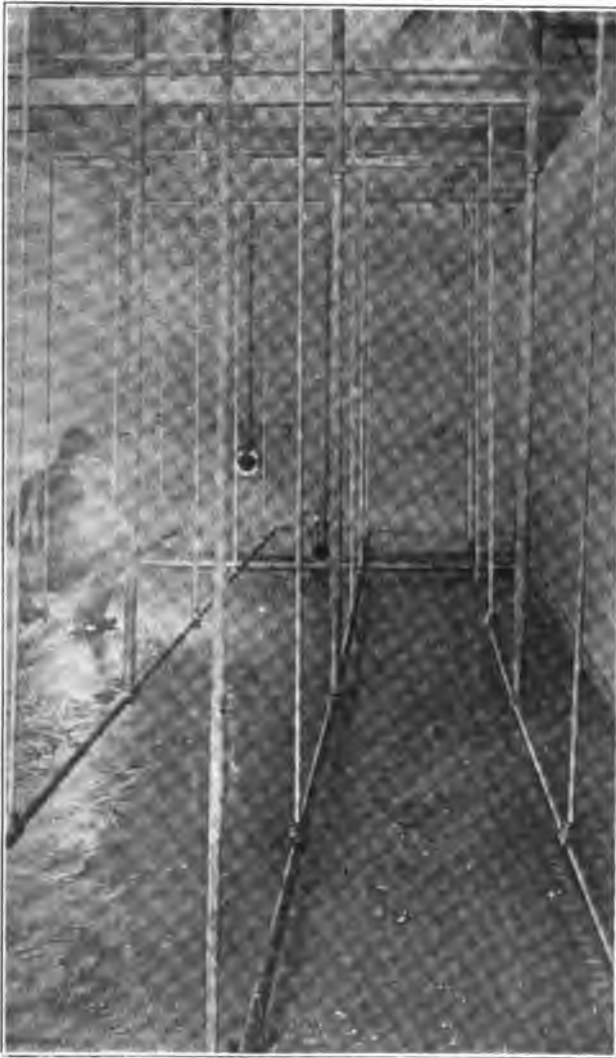


Fig. 48. Showing method of supporting grid by means of vertical rods.

sumption at high speed, $5\frac{1}{2}$ kw. per hour. A duplicate motor may be installed later.

General—The whole plant is housed in on account of the low temperatures experienced here in winter; 10 to 20 degrees below zero is not uncommon, and we sometimes have it as low as 40 de-

grees below zero, usually at night. The machinery hall at least will have to be heated in winter, and we are inclined to think that this will prove a considerable added expense, on top of others necessitated by the aerating process. The North Saskatchewan River, into which all our sewage discharges, has a dry-weather flow of about 1,000 cu. ft. pr. sec. and is rich in free oxygen. In summer the flow is very much larger.

CONCLUSION.

The writer has endeavored with the kind assistance of the various experts in charge of each of the plants herein described, to set forth the actual present status of activated sludge as a sewage treatment process. It is evident in glancing over these pages, that while extensive data have been collected, there are a number of desirable data absent. What is observed to be missing is just the very part that we most desired to include, namely, the probable cost of operation under various circumstances, reliability and practicability under a number of different conditions, methods and cost of sludge disposal and the possibility of profit therefrom, etc.

It is obvious from the data presented that the principle offers a method by which sewage may be clarified and rendered as stable as may be desired, but at a substantial cost. Among the principal advantages are freedom from nuisance, small area of land required, and the clear and sparkling effluent that may be secured.

There are some difficulties that concern the design of the plant, which altho troublesome at present may be met and solved by the ingenious designer. Such, for instance, are the method of air distribution, size and shape of tanks, arrangement of baffles, etc. Concerning the design of such a plant but little is settled, and everyone decides for himself.

Every existing plant has its own general design and personal and peculiar features. The various plants agree in differing in essential matters, and in giving different results.

The sludge disposal problem, while progress has been made toward its solution in some places, as at Milwaukee, cannot be considered as finally disposed of, and indeed, until large plants under ordinary working conditions are obliged to cope with it, the full extent and meaning of the problem can scarcely be understood. One

who has studied the sludge de-watering plants at Providence and Worcester can get some idea of what this means.

The production of a highly putrescible sludge in quantities from 15 to 30 cubic yards per million gallons is not to be considered lightly in a plant treating from 10 or 20 or more millions of gallons of sewage daily. We do not doubt that it may be got rid of, but how? The sludge is very moist, water content running as high as $99\frac{1}{2}$ per cent.

It was anticipated that difficulty might be experienced from the effect of cold weather on the activated sludge process. Operation of the plants during the past winter has proved this fear groundless. The specific heat of air is such that but little heat is removed from the sewage.

The plant in Cleveland started the latter part of January and was able to collect sufficient activated sludge for continuous operation in ten days. The loss of heat in the sewage thru the plant is only 1° C. The plant is in a very exposed situation on the lake front, and as seen by the writer was in the midst of ice and snow, with a temperature below freezing. It was apparently unaffected by the cold.

Air distribution troubles have been pretty general. Wherever porous disks or plates of porous material have been the means of application, there has been more or less trouble. In Brooklyn porous disks were used in one tank, and a pipe-grid was used in another. The result was all in favor of the pipe-grid which, after supplying air for aerating a deep sewage tank for two and a half years, is still in good order.

The distribution of air as seen on the surface of the tank contents is more even and less marked with local ebullition in this tank than in any tank seen by the writer in which porous plates are used. The grid should be so designed that it can be drained thru an outlet pipe, and should have a connection with the city water supply, if possible, so that it can be flushed out at times. A steam connection, so that when the tank is empty steam can be turned on to drive out grease, would be a good feature. The pipe-grid should be so designed that there will be no dead ends.

It is true that in laboratory work a higher efficiency may be

gained for the air by securing very fine bubbles, and there may be a "critical size," but one must provide such a design that under working conditions, always subject to unforeseen disturbance, the best average effect can be secured. In a working plant the difference in effect between the "critical size" and the ordinary bubble, does not give advantage enough to overweight the danger of the clogging of very fine porous air distributors. For practical use over a long period, the writer believes that the perforated pipe-grid is as good as the porous plate and will give the plant a better average effluent. With the grid, the air supply is subject to very small variation in quantity, while with the porous plate, great variation is possible from clogging, which is even caused from microscopic dust carried by the air.

Forecasts as to the value of the activated sludge process for sewage treatment seem to the writer undesirable at this time. The principle of activation is of great interest, and fortunately, experimental work is going forward on a large scale under the direction of some of the ablest men in the country for this kind of work.

ACKNOWLEDGMENTS.

The thanks of the writer of this paper are extended to the following, without whose assistance in supplying data, exhibiting plants, and other courtesies, it could not have been prepared:

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Mr. E. E. Sands, City Engineer, Houston, Texas.

Mr. Ashley F. Wilson, Chief Engineer Utilities Company, San Marcos, Texas.

Mr. A. W. Haddow, Acting City Engineer, Edmonton, Alberta, Canada.

Mr. J. Russell Ellis, Acting City Engineer, Regina, Sask., Canada.

Engineering News, Engineering Record, and Municipal Journal, all of New York.

For discussion of this paper see page 439.

A YEAR'S PROGRESS IN ACTIVATED SLUDGE SEWAGE TREATMENT.

By T. Chalkley Hatton, Chief Engineer, Milwaukee Sewerage Commission, Milwaukee, Wis.

At the Dayton convention of the American Society of Municipal Improvements, held October 12 to 15, 1915, the writer presented a paper entitled "The Pioneer Plant for Treating Sewage by the Activated Sludge Process." This paper fully described a plant which the Sewerage Commission of the city of Milwaukee was then constructing for the purpose of determining, by means by a workable size unit, whether the process was adaptable to the conditions existing in Milwaukee, and to solve many problems connected therewith, such as climatic influences, sedimentation characteristics, aeration and sludge disposal. This pioneer plant has now been in almost continuous operation since the 22d of January of this year, and the writer believes that this association will be interested in a summary of the results obtained.

A detail description of the plant with a full set of plans was published in the proceedings of the association for 1915 and need not be repeated in this paper, which will deal entirely with the results obtained and the conclusions to be drawn therefrom.

In my former paper I drew the following conclusion, "the activated sludge process is the best and cheapest process for treating sewage where a high standard of effluent is required, and as it becomes better developed, will supplant sedimentation and sprinkling filters." After one year's further experimentation with the process upon a large scale I have no reason for changing this conclusion. The process has been adopted by the Sewerage Commission of the city of Milwaukee as the one best adapted for treating the sewage of that city and plans for a plant to treat 100,000,000 gallons of sewage per day are now being prepared under the writer's direction.

OPERATION.

The sewage treated by the plant is secured from the outlet of an

intercepting sewer draining the Menominee River Valley and carries a large volume of industrial wastes, the domestic run-off from about 275,000 people, and a very considerable volume of street wash during storms.

There is an improvised grit chamber at the end of the intercepting sewer which operates satisfactorily except after heavy storm flows, when considerable sand is carried into the plant and settles upon the surface of the diffusers. Attached to this sand are particles of waste, water-logged wood, rags and other material, not subject to rapid decomposition, but which form masses of sludge covering a part of the diffusing area and interfering with its uniformity.

The volume passing thru the plant varies in direct ratio to the flow thru the intercepting sewer, and chemical and bacteriological determinations are based upon the average daily flow; samples are taken every one-half hour and composited.

The plant has been operated at rates varying from 650,000 gallons to 2,000,000 gallons per day, with a volume of sludge in the aerating tanks varying from 10 per cent. to 30 per cent., and with a variation in the aerating capacity. Vertical and horizontal flow sedimentation at various velocities has also been tried. In fact the plant has been put thru many stunts to determine both positive and negative results.

Experiments and observations have been made for several months to determine the volume of sludge collected and a satisfactory method of de-watering, drying and reducing the sludge to fertilizer basis, and, while these determinations are not final by any means, as experiments are still being conducted, they have progressed far enough to warrant the writer in drawing approximate conclusions.

The operation of the plant has been conducted under the immediate direction of William R. Copeland, assisted by a staff of civil engineers, chemists and bacteriologists on day and night duty, to the end that nothing should get by which might affect the process or the design of our large plant. Necessarily a great mass of results both negative and positive, has accumulated, and the writer proposes in this paper to mention those parts which he deems of greatest interest to the profession.

SECURING ACTIVATED SLUDGE.

When the continuous flow tanks were first put in operation our work indicated it would require from 30 to 35 days of continuous aeration to secure well activated sludge. In a tank which we put in operation on July 29, and thru which we treated 50,000 gallons per day continuously, good activated sludge was secured in about ten days, at the end of which time the volume of sewage treated was increased to 75,000 gallons.

The general character of well activated sludge can be easily determined by the eye. It has a golden brown color, is quite flocculent and settles very rapidly in a bottle, forming larger flock as it settles.

It has been our practice to measure the amount of activated sludge combined with the raw liquor in the aerating tanks in terms of percentage. This is determined by allowing the mixture to settle one-half hour in a graduated glass cylinder. The half-hour period was chosen because in well activated sludge 77 per cent. settles in 30 minutes in quiescent liquor, 82 per cent. in one hour, 84 per cent. in two hours, and 86 per cent. in three hours.

In order to maintain 25 per cent. of activated sludge in the aerating tanks we have found it necessary to return from the sedimentation tank from 40 to 50 per cent. of the volume of raw liquor being treated, because the liquor drawn from the sedimentation tank is only about one-half sludge. This, of course, means if four hours detention period is desired in the aerating tank for the raw liquor the tank must be proportioned for a six hours detention period or 50 per cent. increase.

This might be overcome by providing secondary sedimentation tanks in which the sludge from preliminary tanks would be settled for one hour, the supernatant liquor run off and the thick settled sludge returned to the aeration tank. By this method the moisture content in the settled sludge in the preliminary sedimentation tank can be reduced from 99 per cent. to about 96 per cent. This method, however, would increase the area and tankage without decreasing the air, and would add to the operations of the process.

AERATION.

The air used for aeration is secured by operating a Connersville positive blower of the Boston type, capable of compressing 2,400 cubic feet of free air per minute to 5 pounds pressure. The compressed air passes thru a filter built into the main pipe and filled with excelsior. From the indications the writer believes that much better results can be obtained by filling this filter with absorbent cotton, altho considerable oil and dust have been intercepted by the excelsior.

The air used is measured by recording air-meters furnished by the General Electric Company, one meter measuring the air used for the aerating tanks and another that used for pumping sludge from the sedimentation tank.

The diffusers consist of filtros plates 12 inches square and $1\frac{1}{2}$ inches thick, furnished by the General Filtration Company, of Rochester, N. Y. There is one square foot of diffuser to 8.5 square feet of tank surface.

Before the filtros plates were set each was tested for porosity under a 2-inch water pressure, and the variation was from 1.85 cubic feet of air per minute per square foot of plate surface to 5.85 cubic feet per minute. This variation has resulted in one tank receiving more air than its neighbor and the liquor passing thru such tank picks up more dissolved oxygen.

This is an objection to the use of filtros plates which I think has been largely overcome since these plates were purchased, the manufacturers exercising more care in the selection of the materials and in testing the finished plates before shipment. Another objection to this type of plate, which is more difficult to overcome, is the frictional loss. In order to saturate the plate when passing the air thru under 5 pounds pressure, there is a frictional loss of $\frac{3}{4}$ pound, and for every cubic foot of air per minute passed thru the plate at this pressure there is an additional loss of $\frac{1}{4}$ pound.

We have recently been experimenting with a wooden block diffuser with very promising results. The block is cut from basswood across grain and is about $\frac{1}{2}$ inch thick, 12 inches long and 3 inches wide. Four blocks are set side-by-side in a casting about $12\frac{1}{2}$ inches square. Our experiments indicate so far that the fric-

tional loss when 5 cubic feet of air per minute under 5 pounds pressure are passing thru plate is about $\frac{1}{2}$ pound. The air is broken up in much smaller bubbles and is better diffused thruout the surface of the plate. If the wood proves satisfactory it has the advantage of being cheaper, obtainable in all markets and easily removed and replaced without injuring the frame, as it is held in place by the pressure due to the swelling. It is quite probable that less air will be required with the wooden diffusers because of the much smaller bubble, which will result in greater saturation. Experiments are now being conducted to try this out.

Uniform diffusion over the entire area of an aerating tank would, of course, be the ideal condition, but in a large plant this is impossible to maintain, and the writer believes that its importance is not sufficient to warrant large expenditures.

The aerating tank which has given the best results in Milwaukee has the following proportions: One square foot of diffusing surface to 5.5 square feet of tank surface. Average depth of liquor, 9 feet; 275 gallons of raw liquor treated per day per square foot of surface. If the tank was 14.5 feet deep the amount of liquor treated could be increased 50 per cent. One cubic foot of aerating tank capacity treats 29 gallons of sewage per day. If wood diffusers are used the indications are that better nitrification with less air could be secured by increasing diffuser area about 35 per cent., thus reducing volume of air passing thru each square foot of diffuser. This very materially decreases size of bubble and increases saturation. The above proportions provide for the activated sludge returned from the sedimentation tank.

A combined sewage at times carries large quantities of mineral and other heavy inorganic matter to the disposal plant. This matter settles upon the surface of the diffusers and interferes with their efficiency. It is, therefore, quite important that a satisfactory grit chamber form a part of every disposal plant of this character treating combined sewage.

Considerable thought has been given to the question of fine-screening the sewage. The writer is of the opinion that this is unnecessary. It adds to the expense and diminishes the value, as a fertilizer, of the sludge.

Mr. George T. Hammond is making some experiments on fine and coarse-screened sewage in connection with the activated sludge process, and will likely settle this problem beyond question.

EFFECT OF LOW TEMPERATURES.

The Milwaukee plant was put in operation about January 22, 1916, and by February 1 was in continuous operation. During February, March and April the temperature of the sewage varied from 34° F. to 50° F. and the outside air from -14° F. to +69° F. During this time the plant produced an effluent stable for 108 hours, 98 per cent. removal of suspended matters, 97 per cent. removal of bacteria at 37° C. and 83 per cent. oxygen consumed, but required about 50 per cent. more air than when the temperature of the sewage is above 50° F. In other words, the principal effect low temperature has upon the process is additional air requirement.

SEDIMENTATION.

Next to sludge disposal the most important problem studied at Milwaukee during the last six months has been sedimentation. Soon after the plant was placed in operation it was clearly proven that the sedimentation tank was not properly designed to take care of activated sludge. This tank was of central-feed vertical-flow type, with bottom sloping at 45° towards a central well 4 feet in diameter and 34 feet deep below liquor surface.

It was expected that the sludge would separate from the liquor while passing from the center feed, 3 feet below water surface, to a weir forming the circumference of the 30-foot-diameter tank, and falling upon the sloping bottom to the central well would become compressed, due to 34 feet of head of water, and would contain about 96 per cent. moisture, in which condition it would be pumped back by air into the raw sewage channel, by which it would enter the aerating tanks.

It was found that the entrance velocity was too great; that adverse currents were established which held the finer flock in suspension, permitting it to pass over the weir with the effluent; the heavier sludge would settle upon the sloping bottom and not slide down

to the central well, but stick upon this bottom and become septic. While much of the sludge would reach the central well there was not enough of it to keep the aerating tanks well seeded unless an excessive volume of the nitrified liquor was returned with the sludge. This extra liquor decreased the detention period in the aerating tanks, and correspondingly reduced the aeration.

To increase the sedimentation area No. 11 sludge tank was improvised into a horizontal-flow sedimentation tank. It was soon learned that a horizontal flow at the rate of 3 feet per minute was sufficient to give good sedimentation, but there was nothing gained in a great length of flow. In the first experiment the length of flow was about 100 feet with 6 feet 3 inches width of channel. This successfully treated about 400,000 gallons of liquor per day. Subsequently this channel was divided into three separate sedimentation channels and satisfactorily treated about 700,000 gallons.

From our experiments so far conducted upon sedimentation the indications are that the proper type tank is a long narrow vertical-flow tank with the liquor passing across the narrow dimension. The depth seems to have little influence except that it should be such that the bottom be formed as a cone with sides sloping 69° or more from the horizontal. The draw-off pipe should form the apex.

The sedimentation tank which has given the best results in Milwaukee has the following proportions: Ratio of breadth to length is as 1 is to 2.3 with flow across the breadth. One cubic foot of capacity to 281 gallons of sewage treated per day. One square foot area to 1,622 gallons of sewage treated per day. Effluent from aerating tank fed directly into sedimentation tank under a baffle 32 inches below surface of liquor in the latter tank.

It is desirable to build the sedimentation tanks in small connected units for two reasons, to decrease the depth, owing to slope of sides necessary, and to provide for maintaining a sludge blanket, which cannot be done in a large tank. This sludge blanket acts as a filter for intercepting the light floating matters carried to the sedimentation tank. It is not necessary in order to secure a stable effluent, but only to procure one which is perfectly clear.

SLUDGE DISPOSAL.

Nearly every engineer engaged in designing sewage disposal

plants who has visited our plant has freely admitted that the process secured most remarkable results in the treatment of sewage, but expressed doubts as to the possibility of disposing of the sludge by reducing it to a marketable fertilizer within reasonable cost. Realizing that this was one of the most important problems to solve we have given it our most earnest study during this year; have conducted a great many workable-size experiments, and feel warranted in drawing approximate conclusions.

H. R. Worthington, of New York City, erected at our station a sludge press designed by Mr. Berrigan. This press was in operation early this year, and has been in service intermittently up to date.

The Simplex Ejector Company, of Chicago, also erected and is now operating a sludge press under our direction to determine its ability to do better than the Berrigan press.

Several runs have been made with the Smith type of indirect steam dryers operated at the Plankinton packing house in this city, to determine the ability of this type of dryer to treat the activated sludge and incidentally the cost. These runs involved the drying of from 3,000 pounds to 6,000 pounds per run, during which time all information was secured to determine power, labor and steam used and character of escaping gases.

In addition to this, small experiments have been made with a direct-heat dryer manufactured by the Buckeye Dryer Company, of London, Ohio, which gave such promise as to economy and character of product that we have ordered one to be made, which we hope to have in operation by the latter part of September. From the experiments made with this dryer its manufacturer has submitted a proposition, containing guarantees as to cost of operation, for erecting sufficient dryers to take care of our product.

We, therefore, feel that we have secured sufficient information to conclude that there is no difficulty in reducing the Milwaukee sludge to a marketable low-grade fertilizer at less than its value.

The conclusions stated in this paper regarding pressing of sludge have been reached solely from the operation of the Berrigan press. The experiments with the Simplex press were begun at the time this paper was being prepared.

After operating the Berrigan press for several months continuously, during which time many improvements were made thereto, the amount of sludge cake produced in one pressing increased from 70 pounds to 1,700 pounds with an average moisture content of 75 per cent. With a trial run with our own men, and with the crude facilities for handling the material, 6,000 pounds of pressed cake were produced in one day. This can easily be increased to 8,000 pounds, or five pressings, per day when proper apparatus is provided.

One direct heat dryer can produce 25 tons per day, or about 1 ton per hour, of dried material containing 10 per cent. moisture from pressed cake containing 75 per cent. moisture. With mechanical stokers attached to the dryers and proper mechanical devices provided for feeding the dryers with raw material and for taking away the dried product the labor cost can be reduced to a minimum in case direct heat dryers are used. With indirect steam dryers the labor costs would be considerably increased, as the operation is intermittent and the dryers must frequently be partially cleaned by hand.

On the other hand, the gases from the direct heat dryers are more pungent and difficult to handle than those from the indirect dryers, but with a dryer plant located close by the aerating tanks, the gases, after being washed, can be discharged into the aerating tanks under the surface of the water, which will absorb the odors.

Several runs have been made with our plant to determine the volume of sludge containing 10 per cent. moisture produced per million gallons of sewage treated. These runs have extended over two or three weeks and there has been great variation in the results. The average, however, indicates that 1,000,000 gallons of the Milwaukee sewage will produce from 750 to 1,000 pounds of sludge containing 10 per cent. moisture.

The activated sludge, as it is pumped from the sedimentation tank, contains about 99 per cent. moisture. If this is allowed to settle in a secondary tank for one hour it is reduced to 96 per cent. moisture. Pressing it reduces it to 75 per cent. moisture and when dried to 10 per cent. moisture its weight is about 25 per cent. of the weight of the pressed cake.

To better illustrate the sludge proportions it might be interest-

ing to describe our method of operation. From the aerating sludge tank which receives the excess settled sludge from the sedimentation tank, 9,990 gallons of sludge containing 99 per cent. moisture is pumped into an elevated wooden circular tank. This is allowed to settle for about one hour and about 7,510 gallons of supernatant liquor siphoned off, leaving 2,480 gallons of sludge containing about 96 per cent. moisture. This sludge is then run by gravity into the press and reduced to 2,874 pounds of cake containing an average of 72 per cent. moisture. The cake is then put into the dryer and reduced to 718 pounds of material containing about 10 per cent. moisture. The above is the description of some representative runs which we have made. The weight of the cake produced is directly proportional to its moisture content and, with the present crude method of gaging, cannot always be uniform with each pressing.

From the data collected from our many experiments, the cost of disposing of the sludge for the 100,000,000-gallon plant being designed for Milwaukee will be approximately as follows:

Pressing Per Dry Ton.

Overhead charges, 10 per cent. of cost.....	\$1.21
Labor, eight hours, three shifts.....	1.36
Cleaning and upkeep of bags.....	.64
Power .....	.09
Contingencies .....	.16
Total cost of pressing exclusive of building.....	<u>\$3.46</u>

Drying Per Dry Ton.

Overhead charges, 15 per cent. of cost.....	\$.39
Labor, eight hours, three shifts.....	.73
Fuel, 1 cent per 32,000 B. t. u.....	1.10
Power, 1 cent per kw. hr.....	.52
Contingencies .....	.13
Total cost of drying exclusive of building.....	<u>2.87</u>
Total cost of dewatering sludge per dry ton.....	<u>\$6.33</u>

These costs, when reduced to the million gallons of sewage treated, become \$1.73 for pressing and \$1.44 for drying, or a total of \$3.17.

The cost of pumping sludge from settling tank to press is not included in above because the height to which the sludge must be lifted has not been determined.

We have now pressed and dried several tons of sludge, and the analyses show an average of 5 per cent. of available ammoniacal nitrogen in the product. In normal times this is worth \$2.50 a

per cent. or \$12.50 per dry ton at the plant. If shipped to the eastern market the freight is \$1.05, which will be met from the value of the available phosphoric acid and potash contained in the product.

These costs are subject to correction as our experiments progress but the indications are for a reduction rather than an increase and our energies are bent to that end.

Since we have gotten down to the serious study of the sludge-disposal problem we have not found it the bogey which we feared. In fact, it was much easier of solution than many other parts of the process.

One of the good features of the activated sludge is the lack of unpleasant odors. Tons of pressed cake have been dumped into a small wooden shanty, more particularly to keep flies from breeding. The odor at no time during this excessive and long continued hot weather has been objectionable 10 feet away from the building, and now when the door is opened an odor like garden soil is the only one apparent, and the sludge is gradually drying.

This clearly indicates that in a small plant, which would not warrant the cost of drying, the pressed cake could be stored for months without nuisance, and used as a fertilizer in the locality in which it was produced at such times as may be convenient.

GENERAL NOTES.

The cost of operating the process depends largely upon the overhead charges due to first cost, power and character of effluent required, all of which are bound to vary in different localities.

Any standard effluent can be secured and maintained by varying volume of air used and period of aeration, using a uniform percentage of activated sludge. This activated sludge, however, must be kept in prime condition to get any results, and this process requires a certain amount of air applied for a certain period. This cannot now be determined with a certainty until our present experiments on economy in aeration are completed, but so far we have been able to maintain good sludge by using 1.5 cubic feet of air per gallon of sewage treated and a contact period of 4 hours, that is when the temperature of the sewage is over 50° F. Below this

about 50 per cent. more air is required in the same period of contact.

We get good results by mixing from 5 per cent. to 20 per cent. of activated sludge with the raw sewage. This 5 per cent. variation seems to produce no important difference in the character of effluent.

We have been successfully treating in our south experimental tank for the past eleven months at the rate of 9.46 million gallons per acre per day. Since this tank has been improved we have boosted the rate to 10 million gallons and expect to go higher.

One point must be kept well in mind. The mixture of sewage and sludge as it discharges from the aerating tanks cannot be carried in conduits unless it is constantly agitated, as the sludge will settle in the conduits immediately.

The writer has endeavored to give you the best and latest information upon this subject which he has with the understanding that much of it is subject to correction due to further research which he is making. It has been the policy of many engineers to refrain from making public any information upon matters of this kind until conclusions beyond correction could be drawn, but the writer feels that all engineers engaged in sewage disposal problems are so deeply interested in the activated sludge process that he may be excused in giving them data which may subsequently have to be corrected.

For discussion of this paper see page 439.

**A FEW FIGURES ON THE BUILDING AND OPERATION
OF THE BALTIMORE SEWAGE DISPOSAL PLANT,
AND NOTES ON THE ACTIVATED SLUDGE
EXPERIMENTS.**

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Consulting Engineers. Formerly Acting Division Engineer,
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From 1909 to the end of 1915 the speaker was employed as engineer with the Baltimore Sewerage Commission and was stationed almost continuously at the Back River disposal plant. His duties developed so that during the last year he was in charge of operation and the completion of construction work, reporting to Mr. Calvin W. Hendrick, Chief Engineer of the Commission.

The present paper aims to briefly touch on various features of the plant which may be of interest to engineers and others engaged on similar work. There will be given descriptions of Baltimore conditions and analyses of the raw sewage; the layout of the plant and cost of construction; a table showing the maintenance and operation charges; notes on how operation was begun in seven new Imhoff tanks. The paper will close with a brief description of some features encountered in a set of experiments on activated sludge.

BALTIMORE, CHARACTER OF SEWAGE, SEWERAGE SYSTEM.

Baltimore is a city of 600,000 people and has an area of about 32 square miles. It is situated near the head of Chesapeake Bay, and to protect the great oyster beds in the bay, Baltimore was compelled to treat its sewage. The city sewage is mainly of a domestic nature as the proportion of industrial wastes is rather small. The city now has nearly complete sets of sanitary sewers and storm water drains, and many of the manufacturing plants are connected to the latter, when analyses of these wastes prove them fit to be discharged into the harbor and neighboring streams.

The outfall sewer, bringing the city sewage to the Back River

disposal plant, is a little less than six miles long. The length of travel from some of the outlying districts is as much as twelve miles. The result is that when the sewage reaches the plant it is entirely lacking in dissolved oxygen and is at the point of becoming septic. For the last few years, analyses of the raw sewage at the plant show it becoming stronger and more concentrated, 'due, perhaps, to the exclusion of trench and surface waters as sewer construction reaches completion. The speaker deems it inadvisable to base conclusions on the analyses of raw sewage given in the table below, as correct average figures cannot be obtained until all construction work on the sewers is finished.

TABLE I.
Average Analyses of Baltimore Raw Sewage.

Year	Total Solids Suspended	Nitrogen as Free Ammonia	Dissolved Oxygen Consumed	Bacteria	
	p.p.m.	p.p.m.	p.p.m.	Total per c.c.	Red Colonies per c.c.
1912	54.3	7.28	23.5	400,000	56,000
1913	122.1	13.4	114.9	1,650,000	357,000
1914	120	18.7	181	2,800,000	150,000
1915	256	24	113	1,110,000	160,000

It has taken eleven years time and the expenditure of about \$23,000,000 to build sewers and drains for the city and build the outfall sewer and disposal plant. All the main parts of the work have been designed and built for a future population of 1,000,000 persons. The disposal plant, at present, can take care of the sewage of 600,000 persons and space is provided for enlargements.

DESIGN AND CONSTRUCTION.

As the plant was originally laid out, it was contemplated that the sewage be rough-screened, metered, settled in hydrolytic tanks, treated thru broken-stone sprinkling filters, settled in final basins and allowed to flow into Back River, the head of sewage after leaving the basins being utilized to generate electricity for operation purposes. The sludge was to be periodically drawn from the hydrolytic tanks, digested in separate sludge tanks and dried on sand beds. This plan was carried out for part of the plant, but in 1913, when it was decided to bring the capacity up to 600,000 people, Imhoff tanks instead of hydrolytic tanks, deeper sludge tanks, thinner sludge beds, revolving fine screens to protect the filters and a sand bed to handle the sediment from the final basins were built.

Excluding the cost of ground, consulting engineers' charges, chief engineer's salary, etc., the money spent in constructing the plant capable of treating the sewage of 600,000 people, amounted to \$2,375,000. Engineering costs, including costs of design, inspection, giving line and grade, division engineers' office expenses, etc., at 4.32 per cent. or \$102,600, bring the total costs in round numbers to \$2,480,000. Dividing this by 600,000 it is seen that to build the plant it cost each contributing person \$4.13.

Unit costs of the more interesting parts of the plant are as follows:

TABLE II.

One acre of sprinkling filter, broken stone from 2½ to 1 inch diameter, 8½ feet deep, nozzles spaced 15 feet on the square, and including influent and effluent conduits and proportional parts of control house; to be dosed at rate of 2½ million gallons of settled sewage per day, cost.....	\$51,500
28 circular Imhoff tanks, 40 feet in diameter, 25 feet deep, including influent and effluent conduits; to be dosed at rate of 14 million gallons per day, cost.....	63,950
44,525 square feet of sludge beds, composed of 4 inches of sand on 8 to 11 inches of gravel, to take care of the sludge from 140,000 people, cost	11,400

COSTS OF MAINTENANCE AND OPERATION.

In the table below are given unit costs of treating the sewage since operation began. The figures in this and the next following table do not include interest or depreciation on the plant or the chief engineer's salary. All money spent on labor, materials, salaries of chemists, superintendent, machinists, etc., for the operation and maintenance of the plant are included:

TABLE III.

Year.	Million Gallons Treated.	Cost per Million Gallons.
1912	4,321	\$4.86
1913	6,598	4.80
1914	8,503	4.50
Oct., 1914, to Sept., 1915..	10,343	3.58

(See below)

In table No. 4 is given a summary of operation and maintenance costs for a year period from October 1, 1914, to September 30, 1915, and divided, as far as possible, under various headings of the work:

TABLE IV.

Total cost of maintenance and operation.....	\$36,997.13
Sewage flow as measured by Venturi meter (mil. gals.).....	10,343.57
Average flow per day (mil. gals.).....	26.35
Unit cost of treatment $\frac{36,997.13}{10,343.57}$ equals \$3.53 per mil. gal.	

	Amount	Per ct.
1—Cleaning outfall sewer.....	\$ 585.70	1.6
Scow with vertical shield floated down outfall to remove sludge deposits, which tend to cause sewage to become septic; \$24 spent for supplies, the rest for labor in handling the scow. (Outfall cleaned three times.)		
2—Bar screens	625.75	1.7
Labor cost for hand-raking and removing screenings, 50 to 75 wheelbarrow loads per day. No repairs.		
3—Hydrolytic tanks	1,939.36	5.2
Labor cost for de-watering tanks and removing sludge deposits to separate sludge digestion tanks. Tanks cleaned after an operation period of from six weeks in winter to as low as seven days in summer. Electric current for operation of pumps not included. No materials purchased. (17 cleanings.)		
4—Imhoff tanks	621.47	1.7
50 per cent. for operation labor costs, the rest for making changes and repairs on thirteen new Imhoff tanks, in operation about seven weeks. High figure on account of time spent by chemist and superintendent in watching beginning of operation.		
5—Revolving screens	1,905.51	5.2
33 per cent. for repairs and replacements, the rest for labor on operation and care of machinery. Two screens of the Weand type, 10 ft. long and 12 ft. diameter, covered with 24 and 26-mesh monel metal. No electric current charges.		
6—Butterfly valves	937.42	2.5
Practically all for labor on operation and care of machinery. Three one-man shifts per day to watch revolving screens and butterfly valves. Valves consist of flat plates revolving in the conduits leading to filters and are designed to oscillate the nozzle spray.		
7—Filter beds	1,698.42	4.6
Practically all for labor and supervision, including part of men's time on "fixed posts" in control house. Experience shows that one man working three-quarters of a day can keep the nozzles clean.		
8—Final settling basins.....	1,732.07	4.7
Practically all for labor in pumping out sludge and in skimming off and removing floating scum. (Six cleanings.)		
9—Power plant	10,259.37	27.8
\$308 for gasoline for gas engine; \$660 for repairs and maintenance. Rest for labor and superintendence. A corps of engineers and oilers employed continuously (three eight-hour shifts per day).		
10—Underwater conduits	385.64	1.0
Labor for maintaining a light on the end of river piers and purchase of materials preparatory to cleaning out the conduits.		
11—Sludge beds	4,269.27	11.5
83 per cent. for labor for dosing the beds and removing dried sludge, including a small amount for supervision; 17 per cent. for maintenance and for purchase and spreading of new sand. During the year 11,377 1-yard loads of sludge removed and dumped about 300 ft. away at a cost of 29 cts. per cubic yard.		

12—Water tank and tower.....	309.77	0.8
All for repairing frost jacket and painting all iron work on 100,000-gal. and 35,000-gal. tanks supported on tower 100 ft. high.		
13—Maintenance of grounds.....	2,213.47	6.0
\$62 for materials, rest for labor. This item: grass cutting, repairs to pipe lines, sidewalks, buildings, painting and general work necessary to maintain the appearance of the whole plant.		
14—Machine shop and equipment.....	847.15	2.3
60 per cent. for labor, the rest for materials. Includes all machine shop work in making repairs and replacements. This item as shown is too low, as in many cases the engineers and oilers on shifts in the power house are at work in the machine shop, while their time is continuously charged to power house.		
15—Administration and office building.....	810.48	2.3
Janitor service and general maintenance.		
16—Sanitary laboratory	4,037.29	10.9
95 per cent. for salaries for chemists, bacteriologist, samplers and labor; the rest for chemicals and glassware, etc.		
17—Boat "B. S. C.".....	278.71	0.7
58 per cent. for labor, the rest for general maintenance of 35-ft. river inspection and sampling boat.		
18—Sludge selling	456.44	1.2
All for salaries and labor in keeping account of sludge sold to farmers and in collecting bills. During the year \$2,765 was realized from the sale of 10,382 loads of sludge.		
19—Publicity	100.79	
Salaries of men who take time in showing visitors about and in giving information concerning the plant.		
20—Miscellaneous	2,983.05	8.1
For work which cannot be classified under any of the above heads, such as repairs to tenants' houses, work at Walbrook testing plant, etc.		
Total	\$36,997.13	100.0

OPERATION IN NEW IMHOFF TANKS.

The design of Imhoff tank as constructed at Back River may be seen from Fig. 2, on inset opposite page 424.

Twenty-eight of these tanks were constructed. They were thrown into operation a row at a time so that the flowing-thru period of the hydrolytic tanks would not be too greatly disturbed. The behavior of seven tanks, which were "seeded" differently, was watched so that, if possible, a method could be determined whereby the other tanks would not have to go thru a long "tuning up" period on beginning operation. The tanks were filled or "seeded" as follows:

Tank No. 12—Filled with purified sewage before allowing the raw sewage to enter.

Tank No. 15—Three barrels of lime and filled with purified sewage.

Tank No. 18—Ten wagon loads of wet sludge, 60 pounds of newspapers and filled with purified sewage.

Tank No. 21—Ten wagon loads of wet sludge and filled with purified sewage.

Tank No. 24—Same as Tank No. 21.

Tank No. 26—Empty tank filled with raw sewage and allowed to operate at once.

Tank No. 28—Filled with raw sewage and allowed to stand for seven days before beginning operations.



Fig. 3. Imhoff Tank with Scum Overflowing Gas Stack.

Gas bubbles formed a froth in the gas-stack of each tank and after periods of different length, the froth, of an extremely fluffy nature, overflowed into the sedimentation chambers. Fig. 3 is a view of an overflowing tank.

Observations on the actions of the tanks are recorded in table No. 5. The table is explained by the following key:

TABLE V.

1916 Date	Days from Begin-ning.	Temp. Deg. F.	Tank No. 12	Tank No. 15	Tank No. 18	Tank No. 21	Tank No. 24	Tank No. 26	Tank No. 28
Aug. 14.....	0	All tanks started except No. 28, which was started Aug. 21.							
Aug. 23.....	9	high, 89	a	a	a1 c1 d	a1 c1 d	a1 c1 d	a c1 d	a c d2
Aug. 25.....	11	low, 56	d1	a1 c d3	a1 c1 d1	a1 c1	a1 c1	a c1	a1 c
Aug. 27.....	13	mean, 75			a3 b c2 d2	a3 b1 c2 d2	a3 b c2 d2	b c	b c d2
Aug. 28.....	14				a3 b1	a3 b1	a3 b1 c1	a1	a1 c
Sept. 2.....	19				a3	a3	a3	a3	a3
Sept. 4.....	21	high, 93	a1	a2 b	a3	a2 c1	a3	a3	a3
Sept. 8.....	25	low, 46	a3 b	a2	a3	a2	a3	a3	a3
Sept. 11.....	28	mean, 69	a3	a2	a2	a2	a2	a3	a3
Sept. 15.....	32		d3	d3	a1	a2	a2	a3	a3
Sept. 20.....	37				a2 b1 c	a2 b1 c	a2 b1 c	a3 b1	a3 b1
Sept. 23.....	40				a1	a2	a2	a3	a3
Sept. 28.....	45								
Oct. 5.....	52	high, 80	a2 b3	a1 b2 d3	a1 b2 d2	a1 b2 d2	a1 b2 d2	a2 b2 d3	a3 b1 d3
Oct. 6.....	53	low, 38	a2	a2	a2	a2	a2	a2 c1	a2
Oct. 13.....	60	mean, 58	a2 b1	a2 b1 d3	a2 b1 • d1	a2 b1 d1	a2 b1 d1	a2 b1 d2	a2 b1 c1
Oct. 20.....	67								
Nov. 16.....	94	high, 76							
Nov. 19.....	97	low, 31							
		mean, 46							

Oct. 19—Tank No. 18—78.2 cu. yds. sludge removed.

Oct. 19—Tank No. 24—36.2 cu. yds. sludge removed.

Oct. 19—Tank No. 26—6.7 cu. yds. sludge removed.

*175 wheelbarrow loads of floating sludge shoveled out of stack.

KEY TO TABLE V.

a—Scum inside gas stack $\frac{1}{4}$ to 1 inch thick.

a1—Scum inside gas stack 1 to 12 inches thick.

a2—Scum inside gas stack 12 to 36 inches thick.

a3—Scum inside gas stack frothing and flowing over the top.

b—Scum on sedimentation chamber surface $\frac{1}{4}$ inch thick.

b1—Scum on sedimentation chamber surface 1 inch thick.

b2—Scum on sedimentation chamber surface 1 to 3 inches thick.

b3—Scum on sedimentation chamber surface 3 to 6 inches thick.

c—Slow bubbling in gas stack.

c1—Moderate bubbling in gas stack.

c2—Rapid bubbling in gas stack.

c3—Violent bubbling in gas stack.

d—No bad smell over gas stack.

d1—Musty smell over gas stack.

d2—Sour smell over gas stack.

d3—Bad smell over gas stack.

d4—Very bad smell over gas stack.

The flow of sewage thru the tanks during the set of observations was at the capacity for which they were designed. It is noticed that scum formed in all the tanks and overflowed the gas stacks. Probably this would not have happened had operation been begun in cooler weather. While information derived from the observations is not clear-cut and definite, it can be said that the behavior of tank No. 18, seeded with sludge and newspapers, was better than that of any other tank. In this tank the period of frothing was over soonest and at the end of 97 days much more good sludge was drawn from it than from tanks No. 24 or No. 26. (78.2 cubic yards is a little more than half the sludge volume of the tank.) On the 94th day, when 175 wheel-barrow loads of soft floating black sludge were shoveled from the gas stack of No. 18, there was a hard crust of dry matter in the stack 15 inches thick. This being removed, the sludge continued pushing to the surface till all was removed. The speaker thinks that the addition of the papers in the sludge hopper of tank No. 18 very much aided digestion of the sludge, the paper pulp creating quantities of gas-forming cellulose-feeding bacteria which tended to stir up the accumulating sludge and to promote digestion thruout the sludge on the same bacterial basis.

Odors arising from tank No. 15, which was seeded with three barrels of lime, were worse than those from any other tank. The speaker cannot account for this. Perhaps acid-forming bacteria were able to multiply much more rapidly, after the effects of the lime had become dissipated, because formations antagonistic to their growth were singularly lacking in the sludge liquids.

Up to the present time, matted crusts form on the surface inside the gas stacks of all tanks. This is broken up at intervals with rakes or a hose.

During the last winter operation was begun in the second row of tanks with a sewage flow of half capacity. The speaker was told that the behavior in all the tanks was satisfactory and that no froth overflowed any of the stacks.

ACTIVATED SLUDGE EXPERIMENTS.

The experiments on activated sludge at Back River, begun last year, and still being carried on, contemplate operation on the con-

tinuous flow basis in a fairly deep tank. The work is being done jointly by the city of Baltimore and the U. S. Public Health Service, Messrs. Hendrick and Frank being in charge. To date, but little of importance has been accomplished and progress has been hindered by negative results, breakdowns and mechanical difficulties.

In a set of laboratory experiments in 4-liter bottles during the spring of 1915, a good effluent was obtained by aerating for three hours mixtures of raw sewage and prepared sludge. At the conclusion of the bottle tests, the activated sludge from one of the bottles was set in an open container and covered with water. For over a month during the summer, no odor, other than that of mouldy leaves, was produced by the sludge. The sludge contents of another bottle were used to fertilize soil in a flower pot in which wheat was planted. Another pot was filled with the same character of soil, but unfertilized, and wheat planted. The grain sprouted and grew at practically the same rate in both pots. An analysis of the sludge used showed a nitrogen content of 4.39 per cent. on a dry basis.

One of the circular Imhoff tanks was rearranged and used for the large-scale experiment. The raw sewage is made to flow into the tank thru the sludge pipe, entering at the extreme bottom. About two feet above this point is arranged a grid of pipes tipped with porous material and connected to the air blower. The mixture of sludge and sewage rises to the top of the cone and flows into the sedimentation chamber thru holes cut in the sides of the gas stack. The clarified effluent radiates and passes out of the tank over the 50 circumferential weirs, while the subsiding sludge particles slide down to and thru the slot and again mix with sewage in the agitation chamber. The surface of the air-diffuser plates is about 22 ft. 6 in. below the flow line.

At the beginning of the test, 79 carborundum discs 6 in. by 1 in., 120 grit, were used for porous material. Fig. 4 shows the grid of pipes and discs assembled and ready to be installed in the tank.

Carborundum was chosen because of the exceedingly fine bubbles produced in blowing air thru it in a laboratory test. At the time, it



Fig. 4. Air diffuser system.

was felt that the extra head lost in forcing air thru the dense material was not of comparative importance. Air was supplied by a rotary blower and was strained thru six feet of gravel and sand to remove dust and oil.

It was soon noticed that the air pressure at the blower which at the beginning registered 11 pounds per sq. in., soon began to rise till after three months' operation the maximum pressure was as high as 23 pounds. This naturally reduced the air supply and put undue strains upon the blower, which was designed for a working pressure of about 10 pounds. On removing the carborundum discs, the under side of each one was found to be coated with a film of oil, which acted to increase the friction of air thru the material. On breaking a disc no oil could be detected beyond 1-16 in. from the space. This oil must have passed thru the "air washer" in the form of vapor.

Brass plates punched with 1-32 in. holes were next used to break up the air on introducing it into the tank. They were removed before any serious clogging occurred in them. It was felt that the air bubbles passing the holes were too large to be properly effective.

Filtros discs are at present being used for porous material. The speaker understands that one of these discs on being removed after about a month's use, showed the underside to have become quite soft and capable of being indented with the finger nail.



Fig. 5. Prof. Earle B. Phelps and Leslie C. Frank looking at activated sludge tank.

On beginning operation in the converted Imhoff tank, enough final basin sludge was dumped into the tank to give a sludge ratio of about 25 per cent on an hour's subsidence in a tube. The tank full of raw sewage and sludge was aerated for twelve days in which time the sludge turned a golden brown color, and a flaky appearance, and analysis of the clarified effluent showed quite a degree of purification. A small stream of sewage was then allowed to flow thru the tank and in two days' time the sludge lost its vitality and the effluent became nothing but settled sewage. The flow was cut off and the sludge ratio brought up to 30 per cent by dumping in more final basin sludge. Aeration then was continued for a month, when again a small stream of sewage was passed thru the tank. The effluent was clear, stable and sparkling and continued so for quite some time till the sludge again lost its power and the sewage flow had to be stopped. During this time, readings had shown that the sludge, instead of accumulating, was disappearing in an unaccountable manner. No evidence of sludge particles in any quantity had been noticed passing off with the effluent; in fact, the decrease was more rapid when no sewage was being passed thru the tank. The sludge ratio dropped to as low as 8 per cent and the speaker understands that at one time, within a comparatively

short period and with no flow of sewage, the ratio dropped from 60 per cent to 12 per cent.

Some of the results of the experiments at Back River, while at complete variance with those at other plants, cannot help but point out the way to a final solution of the activated sludge problem.

For discussion of this paper see page 439.

DIGESTION OF ACTIVATED SLUDGE.

*By Harrison P. Eddy, of Metcalf and Eddy, Consulting Engineers,
Boston, Mass.*

Among the industrial wastes disposal problems which have been troublesome in Massachusetts during the past decade, is that of a large sheepskin tannery. While a satisfactory effluent can be produced by any one of several different methods, investigations have been carried out to determine by actual test their practicability and efficiency, with a view to ascertaining which is the best method for adoption.

These investigations have included the construction and operation for over a year of a trickling filter and, for nearly a year, of an activated sludge plant. Both processes have been demonstrated to be applicable to the treatment of these wastes. The latter appears to require as much as 10 cu. ft. of free air per gallon of wastes treated and that the aeration be continued for a period of about 12 hours. Quiescent sedimentation for two hours is required for efficient removal of the suspended matter after aeration.

Under these conditions the clarification and oxidation may be expected to be fully equal to and probably better than those obtained by a trickling filter 7½ ft. deep operating at a rate of 750,000 gal. per acre per day.

The wastes used for these tests were first passed thru sedimentation tanks to remove the major portion of the suspended solids, in order to prevent the accumulation of a large quantity of very heavy matter in the aerating tank. This preliminary treatment also provided for equalizing the quality of the wastes.

Because of this treatment the sludge produced by the activated sludge process consisted principally of substances which had been in colloidal or dissolved condition and it may have been more susceptible to bacterial attack than sludge comprising the coarse suspended matter, as well as substance precipitated from colloidal and dissolved condition.

The settled wastes were much stronger than average unsettled municipal sewage, as shown by Table I.

Table I—Analyses of Settled Tannery Wastes and Unsettled Municipal Sewage.

Determination	Settled Tannery Wastes	Unsettled
	March 6-July 17 p. p. m.	Worcester, Mass. Sewage, p. p. m.
Oxygen consumed	702	193
Albuminoid ammonia	14.4	7.1
Total solids	2,740	882
Loss on ignition	635	429

The results of these analyses indicate that the tannery wastes, even after efficient sedimentation, were in a general way three times as strong as the municipal sewage of the city of Worcester. Furthermore, the wastes contained large quantities of fats, originating partly in the tannery proper and partly in the wool scouring department. The fats, determined by extraction with ether, amounted to about 140 p.p.m. In addition, about an equal quantity of fat was present in the form of soaps.

Sludge Accumulation Period. The tests were begun December 29, 1915, and while there was a gradual accumulation of sludge, it early became evident that the process of activating the sludge would be exceedingly slow, as the temperature of the wastes was below 50 degrees F. The wastes were therefore warmed to about 70 degrees F., by discharging live steam into the aerating tank for the necessary period of time. The quantity of sludge accumulated gradually until the end of the period, February 7, 1916, when it amounted to about 20 per cent. of the normal capacity of the tank, equivalent to about 25 per cent. of its influent capacity.

The sludge produced at first was similar to that resulting from plain sedimentation, except that it was less dense. When the treatment began to be effective the sludge became coarse and feathery in nature and purplish-brown in color. Later it lost the purple color and the flocks became finer. Records of the quantity of air used, of temperature, volume of sludge produced, proportion of water in the

sludge, and data relating to digestion, for this and succeeding periods, are given in Table II.

During this period 11,030 gal. of sludge per million gallons of influent were produced and accumulated in the aeration tank. The results of analyses of samples carefully taken indicate that about 71 per cent. of the organic substances removed from the sewage were unaccounted for by the analysis of the sludge.

Sludge Activation Period. With a view to increasing the activity of the sludge, the contents of the tank, after being filled on February 7, were continuously aerated until March 6, no wastes being introduced between these dates. The loss of organic matter during this period amounted to 40 per cent., the volume of sludge being reduced 62.4 per cent. It is somewhat surprising to find that the actual reduction in solid matters was very much less than during the previous period of one filling a day. One explanation of this difference may be that during the earlier period the larger volume of wastes aerated, in proportion to sludge, provided a larger quantity of matter easily attacked by bacteria, whereas during the second period the sludge had already been worked over by them for a considerable time.

On one occasion, thru an error, the air was turned on at full pressure, causing the violent agitation of the tank contents. This resulted in a marked disintegration of the sludge, after which settled samples from the aeration tank were decidedly muddy in appearance. The fine suspended matter into which the sludge had been broken up did not re-coagulate on further normal aeration.

Period of Operation on One Filling per Day. Beginning March 6 the aeration tank was put into operation again on a schedule of one filling each working day, the contents of the tank being heated by the introduction of live steam to a temperature of about 70 degrees F. During this period the total quantity of sludge increased over 100 per cent., altho the average quantity present per filling was but 24.3 per cent. of the influent. The sludge became darker in color and more flocculent. When freshly collected it had only a slight earthy odor, but on standing over night developed a disagreeable fishy smell.

TABLE II.—DATA RELATING TO DIGESTION OF ACTIVATED SLUDGE

Period	No. of Cu. Ft. Free Air Used per Gal. of Influent	Av. Temperature in Aeration Tank, °F.	Volume of Sludge Produced to Date, Gal. per m.g.	Proportion of Water in Sludge, %	Quantity Removed from Wastes, lb. per m.g.	Quantity Found in Sludge, lb. per m.g.	Lb. per m.g.	Quantity Digested %
Dec. 29-Feb. 7 (Sludge accum. period)	12.20	59.3	11,030	98.6	...	...	...	...
Total Solids	3,811	1,225	2,586	67.9
Organic Matter	2,840	815	2,025	71.3
Mineral Matter	971	410	561	57.3
Fats	995	Not determined.	...	...
Feb. 7-Mar. 6 (Period of Sludge Activation)	4.57	67.1	(Period of continuous aeration.)	...	...	...	...	...
Total Solids	30.1
Organic Matter	40.7
Mineral Matter	18.1
Fats
Mar. 6-Apr. 3 (Period of 1 Filling Daily)	17.19	...	5,410	97.24	...	...	...	...
Artificial heat	...	69.5	...	...	...	...	...	...
Total Solids	6,280	2,862	3,868	62.1
Organic Matter	4,680	1,675	3,005	62.9
Mineral Matter	1,550	687	863	55.3
Fats	1,470	219	1,251	86.1
Apr. 3-May 1 (Period of 1 Filling Daily)	18.31	...	4,170	97.16	...	...	...	...
Artificial heat	...	69.8	...	...	...	...	...	...
Total Solids	5,420	329	5,081	93.8
Organic Matter	3,980	411	3,569	89.7
Mineral Matter	1,440	—72	1,512	105.0
Fats	1,175	32	1,143	97.3

DIGESTION OF ACTIVATED SLUDGE

[illegible]

*Based on amounts removed from influent and amounts remaining in sludge.

****Nearly 10,000 gal. per gal of influent produced during this period.**

Period of Operation with Increased Proportion of Sludge. The period from April 13 to May 1 was marked by an increase in the proportion of sludge to the quantity of wastes treated. The tank was operated on the basis of one filling each working day and the wastes were artificially heated to approximately 70 degrees F. As there was only a slight accumulation of sludge during the period, the quantity of influent was reduced to increase the proportion of the sludge, which averaged 28.7 per cent. of the influent treated. With this increase in proportion of sludge there was a decrease in the turbidity of the effluent, which had previously been very marked. Most of the samples which were decidedly turbid passed the putrescibility tests, indicating that stability may precede clarification under some circumstances. In spite of the net increase in the volume of sludge in the tank during this period, the total volume of sludge produced per million gallons of wastes treated from the beginning of the test to May 1, was reduced 23 per cent. below the corresponding quantity as of April 3. There was an apparent loss of 93.8 per cent. of total solids and 89 per cent. of organic matter.

Period of Operation on One Filling per Day. The period from May 1 to May 29 differed from the preceding one mainly because artificial heating of the contents of the aeration tank was discontinued. The tank was filled 6 times a week, each filling being aerated for about 21 hours, except that the Saturday filling received about 45 hours' aeration. As in previous periods, the proportion of activated sludge was slightly greater than in the preceding period. The volume of sludge present decreased until May 15 and then increased again, the net increase for the period being 3,150 gal. per million gallons of wastes treated. The total volume of sludge produced per million gallons of wastes treated to June 2, was 3,910 gal., a decrease of 6.2 per cent. from that produced to May 1.

The loss of total solids during this period amounted to 90.1 per cent. and of organic matter to 88 per cent.

Period of Operation on Two Fillings a Day. From May 29 to June 21 the aeration tank was filled twice daily, thus reducing the period of aeration slightly over 50 per cent.

Beginning June 12 the effluent became decidedly muddy in appearance, due to the presence of much finely divided suspended

matter which did not settle out in the period of sedimentation afforded. It was evident that the sludge was becoming disintegrated, but this condition could not have been due to violent agitation, since the air had been applied at only a moderate pressure. The proportion of sludge was much greater than during the preceding period, tho not unreasonably large, being only about 30 per cent. of the total volume aerated.

On June 13 the top water was still muddier in appearance, and aeration was continued for an additional 9 hours with no improvement in the appearance of the effluent. In fact, there was no improvement in the effluent thruout this period, altho air was applied at widely differing rates and different periods of aeration were afforded. The effluent for the week ending June 19 showed 200 p.p.m. of suspended solids.

Altho no sludge had been removed from the aeration tank since the beginning of the tests on December 29, sufficient sludge had not accumulated during the six months to afford as large a proportion of activated sludge as was desired for the tests. It is probable that the long-continued aeration of the sludge had produced a humus-like substance, which became so great in quantity that it could no longer be held mechanically in the body of the sludge, and was drawn off as semi-colloidal non-settling matter.

The fine suspended matter drawn off was comparatively stable, like humus, and the sludge was in a highly activated condition. In fact, it may be said that the unsatisfactory appearance of the effluent was due to over-activation of the sludge. The only remedy appeared to be to remove a portion of this old sludge, with a view to building up a larger proportion of fresh sludge.

Accordingly, on June 21, nearly half of the sludge was removed and the aeration tank continued in operation on two fillings a day. The effluent from the first filling after reducing the proportion of sludge showed no appreciable improvement in clarification, but the effluent from the next filling showed a marked improvement, and after two days the effluent became nearly normal, the suspended matter having been reduced from about 200 p.p.m. on June 21 to about 50 p.p.m. on June 24. The volume of sludge in the aeration tank increased nearly 40 per cent. in eight fillings.

There was a net loss of 13.8 per cent. in the volume of sludge in the tank during the period, but this was not wholly due to bacterial action, as a large quantity of fine disintegrated sludge was carried away in the effluent, as previously mentioned. The volume of sludge produced to June 21 was 2,770 gallons per million gallons of wastes treated, a reduction of 29.2 per cent. from that on June 2.

The loss in total solids during this period amounted to 98.9 per cent. and of organic matter to 96.6 per cent. Computation showed that the loss in total solids from March 6 to June 21, amounted to 82 per cent. and that in organic matter to 80.9 per cent. The loss in fats during this period of somewhat over three months, amounted to 98 per cent.

Period of Operation on Two Fillings a Day, with Removal of Sludge. From June 21 to July 17 the test was continued on two fillings of the tank each day. On June 21 half of the sludge was removed and a rapid accumulation of sludge followed. On July 5 another removal of half of the sludge was made, and again on July 17.

After removing half of the sludge from the aeration tank on June 21, the effluent began to lose its muddy appearance, and on June 24 it had merely a distinct turbidity with suspended matter equivalent to about 50 parts per million. On June 28 the effluent became decidedly turbid and the stability decreased materially. The second day after the removal of about half of the sludge on July 5, the effluent was only slightly turbid and contained only about 18 parts per million of suspended matter. It was perfectly stable.

The total volume of sludge produced during the period was equivalent to nearly 10,000 gallons per million gallons of wastes treated, nearly as much as for the first period. By removing the sludge frequently, time was not allowed for the bacterial action which would have caused liquefaction and gasification. The volume of sludge produced to July 17 was 4,630 gallons per million gallons of wastes treated, an increase of 67 per cent. over that produced prior to June 21. The total solids removed from the wastes, but unaccounted for in the sludge, amounted to 57.5 per cent. and the organic matter to 59.2 per cent. There was a similar loss in fats, amounting to 54.1 per cent.

Sludge Digestion. One of the most significant facts developed by this test, is the disappearance of material removed from the wastes and which at first thought would be expected to be present in the sludge.

It is a law of chemistry that when chemical action takes place the sum of the resulting substances is equal in weight to the sum of the substances entering into the reaction. Matter is indestructible. It follows, therefore, that the amount of solids disappearing must have passed into the atmosphere as gas. It may fairly be assumed that bacterial action was largely responsible for this loss. The liquefaction and gasification of sewage solids by bacteria is called bacterial digestion. By reference to Table II, it will be seen that during this test from December 29 to July 17 there was lost, thru such digestion, 78.1 per cent. of the organic matter removed from the wastes.

Bacterial digestion of organic matter is generally accompanied by an increase in mineral matter. In this case there appears to have been an actual decrease in mineral matter of 77.8 per cent. It is hardly conceivable that bacteria could have digested mineral matter. It is quite possible, however, for mineral matter to be so changed in composition, as a result of bacterial action, that the fixed matter remaining after ignition will have a different weight. For example, calcium nitrate may be precipitated, by carbon dioxide resulting from bacterial action, in the form of calcium carbonate which, after ignition, would be weighed as calcium oxide with an apparent loss of about 56 per cent.

It seems quite certain that chemical action taking place during aeration explains the apparent loss in mineral matter. With such a variety of chemicals as is found in these wastes, it is to be expected that a variety of chemical reactions will take place on aeration. The marked avidity of the wastes for oxygen shows that chemical oxidation takes place on aeration.

Quantity of Sludge Produced. The quantity of sludge which will be produced by the activated sludge process will depend upon the method of operation and the extent to which bacterial digestion of the sludge is carried. The results of these tests show that it is possible to activate the sludge to the point where there is practically no increase in the volume of sludge. To do this undoubt-

edly requires the expenditure of an amount of air greatly in excess of that required to produce a satisfactory effluent.

On the other hand, it does not appear to be possible to accomplish satisfactory purification of the wastes by this process, without considerable digestion of sludge. With the most economical use of air the volume of sludge to be disposed of will probably not exceed 10,000 gallons per million gallons of wastes treated.

During the period of sludge accumulation from December 29 to February 7, there was produced a total of about 11,000 gallons of sludge per million gallons of wastes treated. During the period of sludge activation from February 7 to March 6 this volume was reduced 62 per cent. After operating on one filling a day until May 23 the total volume of sludge produced was less than 3,000 gallons per million gallons of wastes treated. After starting on the schedule of two fillings a day the sludge became more voluminous, but owing to over-activation the volume of sludge decreased until June 21, when the total volume of sludge produced fell to 2,770 gallons per million gallons of wastes treated up to that time. During the period from June 21 to July 17, with occasional removal of sludge from the aeration tank, the sludge production was nearly 10,000 gallons per million gallons of wastes treated. During the latter part of this period the sludge was not kept as well activated as is desirable. With better activation of the sludge the volume would be reduced.

Digestion of Fats. It is particularly interesting to note the digestion of fats which occurred during this test. From the beginning until July 17 the quantity of fats which disappeared and were apparently digested by bacterial action, amounted to 88.7 per cent. of the quantity removed from the influent. This quantity was intrinsically large, amounting to 792 pounds per million gallons, equivalent to nearly 91 parts per million. In other methods applied to the treatment of municipal sewage it has been found that the digestion of fats was a relatively slow process and quite the reverse of the action in this test.

Increasing Volume of Sludge by Its Partial Removal. It appears to be essential to efficient clarification and probably to the production of a stable effluent, to remove the sludge at relatively frequent intervals. If this is not done the sludge becomes over-activated,

resulting in disintegration, a turbid effluent and a reduction in the volume of sludge. By withdrawing a portion of the sludge at regular and frequent intervals, it is to be expected that a larger quantity of sludge will be produced and that it will be of such a character as to perform its function more efficiently than if allowed to remain too long in service.

It is conceivable that under some conditions over-activation of the sludge may be warranted as a means of reducing its volume and the difficulty of its ultimate disposal. This would be where the quantity produced or the ingredients of fertilizing value are too small to warrant an attempt to convert the sludge into marketable fertilizer.

DISCUSSION OF PAPERS ON ACTIVATED SLUDGE.

MR. HATTON: Mr. President, I am authorized to convey to this Society the very affectionate greetings of your first President, George H. Benzenberg. I heard him say a few days ago that in his opinion this Association gives more real work to the solving of municipal problems than any other municipal association in the United States, and I am glad to see that this year we have added to the membership 140, I think, which is speaking very well for a society which a few years ago was on its last legs, as we thought.

There is one other point which I want to explain because I have had some recent information, which was obtained since my paper was printed, and that is in reference to filtros plates. We are making many investigations to determine the best method of diffusing our air. The problem of diffusion of air and the problem of sedimentation are the two which confront Milwaukee now. After operating filtros plates in one of the tanks which Mr. Hammond showed you for eleven months and two days, we took the filtros plates out, and every one of them was in as good condition as the day they were put in, except that the rust from the pipes and the oils carbonized from the blower had closed up about one-third of the underneath-area of some of the plates. But on the whole over 68 per cent. of the surface of the plates was as good as at the time they were put in. There was no softening and no disintegration apparent in any of the plates. Now, in the last month we have had

occasion to clean out all but two of the tanks of the larger plant, and we examined very carefully the character of the filtros plates, of which there were 78 in each tank. Much to our surprise we found a number of plates, not a great number, that had softened and showed disintegration, while others showed no disintegration whatever, and in order to find out what was the matter, we had Mr. Porter, who is the chief chemist and manager for the company manufacturing these plates in Rochester, come to Milwaukee. He did so this last week, and we went over the thing very carefully, and he convinced me that the cause of that disintegration was in the manufacture of the plates; that there was no reason for this disintegration if the plates were properly made. We picked out plates and took them out of the plant that were not disintegrated, and demonstrated, as I say, to my satisfaction, the cause for this softening. I say this because I have mentioned in my paper, and Mr. Frank and others have mentioned the same thing in their papers from time to time, that the filtros plates were likely to disintegrate, and I wanted to make this statement because I was afraid that I was doing an injustice perhaps to the filtros plates. I think that the filtros plates as now made are beyond the possibility of softening after use.

I also want to say just a word about our wooden diffusers. We have just put a tank in with wooden diffusers. We do not know what the results will be, except from our small experiments which we have tried, but we feel we can very largely reduce the amount of air necessary for proper diffusion by these plates. In fact, our experiments have shown that conclusively, on a small scale. The only trouble about the wood plates is the possibility of their life. That is a thing that we can only prove by time, and we propose to prove it in Milwaukee. However that may be, if the wood plates do last as we hope they will, they will make a far better diffuser than the filtros plates—more economical in every way. It is true that diffusing the air thru perforated pipes is a simple matter and might overcome all the disastrous failures which might come from using a filtros plate in the bottom of the tank where they cannot be gotten at, but we feel perfectly sure at our Milwaukee plant from certain small experiments which we have made that the amount of air used by the method of perforated pipes will be too great to make the process attractive to us.

THE PRESIDENT: In Mr. Hatton's paper last year he left two questions open. One was the question of whether the winter conditions would affect the operation of the activated sludge process, and the other was the cost. I think you have answered both of these questions in the meantime, have you not, Mr. Hatton?

MR. HATTON: Well, I can only state from our local conditions. I want it understood that all the statements I make are governed by our local conditions. The only effect of cold weather upon the process is to increase the amount of air about 50 per cent. The cost under normal conditions, so far as we have been able to figure it out, is between six and seven dollars per million gallons treated, without the cost of the sludge. My paper presented yesterday shows that the cost of disposing of the sludge is \$3.17 per million gallons of sewage treated, which will make between nine and ten dollars per million gallons for the entire treatment of the sewage and disposal of the sludge.

I want it understood, however, that that includes overhead charges, which is 7 per cent. on the tanks and equipment, 10 per cent. on the pressing, and 15 per cent. overhead charges for the drying. We assume, and in fact we have very good reasons for the assumption because we have actual data for all of the sludge that we have been producing, a certain value per unit of ammonia. We know how much ammonia we have obtained from the product which we have already produced. We expect to get gross returns from the sludge of about \$6 per million gallons treated. So the net cost of treatment and sludge disposal will be between \$3 and \$4 per million gallons, including all overhead charges. Now we get our power pretty cheap. The Railway Commission of the State of Wisconsin fixes the cost of the power if we take it from the utility companies, and it runs about 0.77 cent per kw.hr. But we propose to put in a 4,000-h.p. unit ourselves, in which case we will manufacture the power considerably cheaper than the utility companies will furnish it to us. In small places where they are treating 5,000,000 or 6,000,000 gallons, it is my impression, from a great deal of thought and care in examining into this question, that instead of paying four or five cents per kw. hr. for current, if they chose to put in their own power they could produce current a great deal cheaper than the average public utility company can

furnish it by the use of the present well-developed oil or gas-producer engine, which can produce electric current in small units at much less cost for both fuel and attention than the small steam-engine plant. I do not think any small municipality need stagger at the cost of the process by reason of the cost of producing the air.

MR. FOLWELL: I would like to ask Mr. Hatton right along that line to inform us about what part of the total cost of the process the power cost was. I think that matter of power is very important. For instance, New York City has a plant in one of its outlying sections operated very largely by electricity. It is paying, as I understand, or was, 5 cents per kw. hr., which you see is seven or eight times as much as Milwaukee is paying. Now if you multiply your power cost by seven or eight, and that forms a considerable part of the total cost of the process, it may mean everything between practicability and impracticability.

MR. HATTON: Leaving out the cost of producing the sludge, or I should say, of reducing the sludge—entirely a separate proposition—the ratio between the cost of the air and the cost of purifying the sewage is about as one is to three. The air costs about two-thirds of the cost of the process.

MR. FOLWELL: Between four and five dollars, then?

MR. HATTON: Between four and five dollars.

MR. FOLWELL: For the air?

MR. HATTON: Yes. Under our conditions.

A MEMBER: I think I worked that out from your report as \$5.30, for the air.

MR. HATTON: That is from one of the old diagrams, made up a year ago. The cost of that has been cut down considerably.

MR. FOLWELL: Do I understand, Mr. Hatton, that means the power, or does that include the overhead?

MR. HATTON: All overhead, except engine room and plant attendance.

MR. FOLWELL: How much that increase cost of current will

increase your total cost you don't know. You don't know what your bill for current would be for a month?

MR. HATTON: No, I cannot say offhand, but we are figuring all overhead charges.

MR. FOLWELL: It might be possibly two dollars that you are paying for power alone for the air supply?

MR. HATTON: Well, that is a very easy thing to determine. Seven-tenths of a cent per kw. hr.—well, I would have to figure it out.

MR. FOLWELL: Speaking roughly, it might be that?

MR. HATTON: Well, we have to figure it down to horse-power, and then count how many cubic feet of air would be produced from the horse-power required.

MR. FOLWELL: If it were only one dollar, that would mean that New York City, for instance, was spending ten or twelve dollars more for treating by activated sludge than by water power.

MR. HATTON: Oh yes, of course.

MR. FOLWELL: It would make it, just as you said, to a certain extent a local proposition. If your current is going to cost you 5 cents per kw. hr., it is entirely out of consideration.

MR. HATTON: I should say so.

MR. FOWLER: It would not have to be more than 2.

MR. HATTON: I agree with you entirely.

A MEMBER: I would say that the cost in New York is not as much as 5 cents. They were paying four at one time, but I think the price in New York is between 2 and 3 cents.

EARLE B. PHELPS, U. S. Public Health Service, (by letter): Mr. Hammond's valuable contribution to this subject suggests an important fact too often overlooked by engineers, namely, the distinction between a process of sewage disposal and an apparatus or device for carrying out that process. The accepted current use of the word process to define the engineering apparatus, such as the trickling filter process, the Imhoff tank process, etc., while con-

venient and quite satisfactory, frequently tends to obscure the essential bio-chemical nature of the treatment in question.

Aside from such purely mechanical treatments as screening and sedimentation and such chemical treatments as lime precipitation, modern sewage disposal is essentially bio-chemical and depends for its successful consummation upon the adaptation of existent natural agencies.

In this sense there are but two essential or basic processes, namely, anaerobic decomposition and aerobic oxidation. In the former, as exemplified in the septic tank or the Imhoff tank, there is a successive hydrolytic cleavage of the primary molecule into secondary and tertiary forms. This process may be likened to the crushing of stone into continuously smaller fragments until it is ultimately reduced to exceedingly fine particles representing the final products of digestion. Aerobic oxidation, on the other hand, proceeds rather by a course which may be likened to erosion, whereby the original molecule remains intact thruout, except for the loss of fully oxidized small particles. One striking difference between these two processes is that, whereas the latter may be stopped at any point short of complete oxidation and will yield thereby results which are directly proportional to the extent of the oxidation process which has been applied, the anaerobic process results in little or no improvement in the character of the sewage or sludge until it has been carried to practical completion. In fact, it seems to be the case that in the preliminary stages of this process the actual character of the sewage or sludge from a nuisance or pollution point of view becomes worse.

Upon these two real processes of organic decomposition all modern bio-chemical methods of sewage treatment are based. Broad irrigation, sand filtration and treatment by trickling filters, represent the one type, while septic, biolytic and Imhoff tanks, represent the other. The contact filter is unique in sewage treatment in that, as the present writer has shown, it utilizes both of these primary principles and in addition a direct chemical reaction between the partially oxidized products of the one process and the partially hydrolyzed products of the other. As Mr. Hammond has pointed out, the oxidizing processes require for their consummation the simultaneous presence of oxygen, organic matter and

oxidizing bacteria. This system is to be found naturally in the soils, and successive improvements in the art of sewage disposal have resulted from the more economic disposal and apportioning of the three essential factors. Thus the sand filter improved upon broad irrigation by providing better drainage and indirectly more efficient aeration. The trickling filter was a further improvement in that the amounts of sewage and air relative to the surfaces available for bacterial growth were greatly increased. It should be noted that there is a coincident decrease in the quality of the effluent.

The new process of artificial aeration represents a still further step in advance in that there is a still more economic apportionment of these three factors. The experiments carried out by General Black and the present writer, alluded to by Mr. Hammond, had this definite purpose. It was held that the trickling filter, representing at that time the highest type of device for carrying out biological oxidation, possessed excessive air space in comparison with the volume of sewage and the amount of bacterial growth. It was believed that by employing a tank having a larger relative water capacity with a minimum of surface for bacterial growth and receiving its oxidation by means of forced aeration, a better proportion of the factors would result. Incidentally it was also desired to obtain by such a device an effluent even less perfectly purified than that of the trickling filter if this result could be obtained at proportional low cost.

In the activated sludge treatment as now carried out the bacteria are grown in the sludge itself rather than upon an artificial structure. It is already satisfactorily demonstrated that in its biological principle this treatment represents a proportioning of the three factors alluded to which is much more nearly the ideal than has hitherto been obtained. With this essential biological factor established there still remains to be determined whether the economies of the process will justify its application. In speaking of this type of treatment, however, as a process, and in dealing with the necessary engineering phases of the treatment, it will be of distinct advantage if the essential biological facts herein set forth are not overlooked.

GEORGE W. FULLER (by letter): The papers of Messrs.

Hammond, Hatton, Eddy and Requardt make a notable record of the development of this new method of sewage treatment by activated sludge. Without doubt this process has come to stay. For some sets of local conditions it is doubtless unnecessarily complete in its efficiency, and for other circumstances its cost will be in excess of that of other methods doing equal or similar work.

For some time the writer has kept closely in touch with the majority of work done along this line. It appears that where high-grade purification is necessary during the warmer season of the year and where only partial clarification is needed at other seasons of the year this method has its greatest field of usefulness.

In first cost the activated sludge method is cheaper ordinarily than are Imhoff tanks and sprinkling filters. As to operating expenses, the cost of power is a material factor and the indications are that for many projects the activated sludge method is not the cheapest means of accomplishing the work locally required.

Where the sewage comes from combined sewers, the storm flows of which have some relationship to the pollution of neighboring water supplies, it would seem to be important to figure on chlorinating such portions of storm flows as cannot readily be passed thru an activated sludge plant. This was the view taken in the report of Messrs. Alvord, Eddy and Fuller to the Trustees of the North Shore Sanitary District, near Chicago.

Mr. Hatton speaks of the flow of combined sewers with respect to the heavy inorganic matter requiring treatment in a satisfactory grit chamber. But is not the total amount of pollution by storm flows such as would require the latter to be by-passed around the aerating tank and adequately treated with liquid chlorine? Data on this point are important.

Messrs. Hammond and Hatton do not speak very encouragingly of fine screens as a helpful factor for regular use preliminary to the activated sludge treatment. Attention is here called to the fact that at the activated sludge plant of the Chicago Sanitary District the sewage and trade wastes are first passed thru a rotary screen with 30 meshes per linear inch. No signs were noted of the fine suspended matter in the screened sewage being incapable of suitable activation.

The treatment of the sludge question as presented to the Society by Messrs. Hatton and Eddy forms an important addition to our practical knowledge. The recovery of the fertilizing properties from activated sludge from large plants so as to use the nitrogen and other plant foods on a commercial basis seems to be capable of realization. The commercial aspects of the problem will doubtless vary materially with numerous local factors. As an engineering proposition the drying of sludge seems to be capable of attainment.

Whether sludge pressing is preferable or cheaper than de-watering by the Dickson yeast fermentation process seems doubtful for reducing the water content from about 95 to 75 per cent. In fact, the limited evidence available suggests that sludge pressing is the more expensive method of the two. More data are here needed.

In connection with Mr. Hammond's description of the Cleveland plant, the statement is noted on page thirty-four that the recovery presumably of the suspended solids in sludge averages about 55 per cent. This statement needs further elucidation, and if it is a fact that suspended solids so disappear in this treatment, then the form in which they disappear should be promptly studied.

Mr. Hommon's statements of his operating experiences at Atlanta are unusually valuable, and designing engineers will read his complete paper with great interest.

ALEXANDER POTTER (by letter): Too much credit cannot be given to those engineers who, having satisfied themselves that their experimental work on some new process indicates a satisfactory solution of some long-standing and exasperating problem, have the courage of their convictions to put such ideas in effect on a broad and comprehensive plan. The prestige of American engineers, especially in the line of sewage disposal, has suffered considerably because of their timidity as a class to do pioneer work. Many of our designs we borrow from abroad, or at least they are mere adaptations of methods tried out successfully in foreign countries. It is a pleasure, therefore, to know that in the field of the activated sludge process of sewage purification we find eminent engineers taking its success for granted and building large

plants for the treatment of the sewage of entire cities. These men, however, are charged with great responsibilities, and it is only fair to ask them to report actual results with the equipment and apparatus with which they are conducting their experimental work, not in terms of what they finally believe they can accomplish when an actual, full-sized plant is constructed and placed in service. As all activated sludge plants already built or under process of construction must of necessity be considered experimental plants, their every heart-beat should be faithfully recorded and reported.

The desire to "hog" the glory of being in the van in the execution of large works built in accordance with some new idea by no means lessens the responsibility of the engineer of such plants to be just as unbiased in reporting the exact facts, and adverse and disappointing results should receive as much notice from the experimenter himself as the plant deserves to receive if it were demonstrated to be a complete success, for otherwise its success would be taken for granted and other plants of a similar nature built which would not otherwise be constructed.

In spite of the large amount of experimentation already carried out, the process of treating sewage by aeration and activation must still be considered as not yet out of the early experimental stage. Many of the problems connected with this process are as yet only partially solved. Its reliability and freedom from breakdown under the severe conditions met with in practice, have not been established. The cost of maintenance and operation also is still undetermined. The results and conclusions reached at the various experimental plants, although promising, are as much at variance as are the structures and devices used for experimentation. As yet no forecast on the value of this process for treating sewage on a large commercial scale is possible based on results actually obtained. Predicated results are based too much upon the opinion and ipse dixit of enthusiasts.

Conclusions based on the short-time tests that have been made are more often than not misleading. In the instance of Milwaukee, based upon the results of preliminary laboratory experiments, activated sludge continuous flow disposal was in 1915 estimated and officially reported to the city authorities to cost \$7.81 per

million gallons treated, made up as follows: for operation, exclusive of disposal of sludge, \$2.00; disposal of sludge, \$3.00; interest and depreciation on the cost of the plant estimated at \$13,700 per million gallons, \$2.81. At an estimated cost of \$7.81 it compares most favorably with the standard method of sewage disposal, namely, Imhoff tanks, sprinkling filters and final settling basins.

Based upon these preliminary experiments and the low estimated cost of operation, the City constructed a workable sized plant on Jones Island, with an estimated capacity of 2,000,000 gallons per day.* The cost of constructing this plant was \$65,000, or \$32,590 per million gallons.** Under actual operating conditions it was found that the cost for air alone for treating 1,000,000 gallons of sewage per day is estimated by Mr. Hatton to be \$5.30 per million gallons**—approximately two and a half times the previously estimated total cost of operation and maintenance, exclusive of sludge disposal, namely, \$2.00, as set forth in the 1915 report. It appears also that the capacity of the plant has been over-rated, and as a result of this over-rating the cost of construction per million gallons works out to be \$46,000 instead of \$32,500 based on the estimated rating of the plant. This latter amount is approximately thirty-five per cent. in excess of the cost of constructing a treatment plant consisting of Imhoff tanks, fine screening, sprinkling filters and final settling basins, such as has been constructed for the City of Baltimore. The actual fixed charges at the Jones Island plant amount to \$7.76 per million gallons as against \$2.81 estimated for a full-sized plant for the city of Milwaukee. Notwithstanding the fact that a full-sized plant can be constructed at a unit cost considerably less than the small-sized experimental plant of 2,000,000 gallons rated capacity, the discrepancy is so great that attention should be called to it.

In his paper before this Society in October, 1915, Mr. Hatton claims that the cost of air per million gallons treated is \$5.30, exclusive of engine-room and plant labor and the disposal of the sludge. As the cost of air seems now to be the whole crux of the matter of activated sludge, it is unfortunate that Mr. Hatton

*See Report of Chief Engineer, 1915, page 32 et seq.

**See paper by T. Chalkley Hatton, Proceedings A. S. M. I., 1915.

did not deem it of sufficient value to record the actual air consumption and the actual cost of producing the air used in the sewage which actually passed through his workable-sized plant during the past year. It is to be hoped that in his closing he will give these figures in detail. The plant at Milwaukee is much larger than the average plant thruout the United States and the equipment as efficient as will be purchased by any city having 2,000,000 gallons of sewage to dispose of; therefore, complete records of the performance of this plant are of great value to the profession as a whole and should be given.

Mr. Hatton's response to the writer's reference to the figure of \$5.30 as the cost given by him a year ago, was not convincing, namely, that that cost was taken from an old report. Such figures, of course, should be taken for granted until revised in detail by the author. Mr. Hatton's first estimate of the cost of air was \$2.00. The writer believes that the actual cost per unit of sewage treated during the past year was even greater than the \$5.30 mentioned in his report.

The advice of several of the experienced experimenters as a result of their studies is to go slowly in adopting this process on a commercial scale. The indications are that tests covering a period of only two or three months, because of their short duration, are apt to be misleading. One fact stands out rather prominently, namely, that in many of the plants designed for a rated working capacity, a considerable reduction was found necessary in the quantity of sewage passed thru the plant to secure satisfactory results. This reduction in capacity amounts in one instance to as much as 50 per cent. As a result, the cost of treatment is from two to three times the estimated cost based on preliminary small-scale experiments.

The activated sludge disposal method possesses a number of advantages over the methods heretofore in use, some of which may prove of such importance that the process may ultimately supplant existing methods for the commercial treatment of sewage. The greatest of these advantages may turn out to be the elimination of the nuisance from odors accompanying many of the standard methods of sewage disposal, especially as it may be possible to

carry on this process near the source of the sewage and before it has become highly putrescible.

A second advantage is that the objectionable portion of the sewage has been reduced to not more than 1 per cent. of the original bulk of the sewage, and consequently its transportation by pumping or otherwise to remote and unobjectionable locations for ultimate disposal will normally involve a far less cost than that of transporting the entire sewage to a remote point for treatment.

Another advantage, but one of considerable importance, is the comparatively small area required for treatment. The process seems to require about one-quarter of the area required for sedimentation and sprinkling filters.

That aeration and activation is an effective method of sewage purification if carried out under proper conditions, cannot be gainsaid. Nevertheless, a studious reserve is maintained by many as to the commercial value of this process. This principally because of the meagre data now available as to the reliability, simplicity and cost of operating this process. Next to efficiency, reliability and simplicity of operation and economy in the cost of construction and maintenance and operation are essential to the success of any system of sewage disposal.

In conclusion the speaker desires to state that the results obtained in the various experimental plants, altho highly promising, are by no means sufficiently conclusive to warrant an engineer, when designing a commercial plant, to guarantee that effective operation will be secured at a cost within the present range of economy now possible with well-established methods of sewage treatment.

The writer believes that the Houston engineer misspoke when he wrote to Mr. Hammond that "we have discontinued any experimental work at Houston," for he owes it to the profession to consider the plant that he is now building as a result of ideas secured from others, a purely experimental one on a full-sized scale. The results obtained from an 18,000,000-gallon plant should prove both interesting and conclusive.

J. RUSSELL ELLIS, Acting City Engineer, Regina, Saskatch-

ewan, Canada, kindly submits the following contribution to the discussion of Mr. Hammond's paper in the form of notes on the experiments with activated sludge carried out at Regina, (by letter):

The reasons for instituting the experiments were as follows:

(1) To establish the practicability of the activated sludge process under our local conditions.

(2) To obtain data which could be applied in the design of a large scale plant if it should be considered feasible to proceed to this extent.

In May, 1915, the work was started by erecting two cylindrical galvanized iron tanks, herein designated as tanks No. 1 and No. 2. A small pump and air compressor, with an air tank, were installed. This experimental plant was erected in the city power house.

Each tank had a diameter of 4 ft. 6 in. and 5 ft. 10 in. high. The working capacity of each was 92.72 cu. ft. or 577.8 Imperial gallons.

The following statement is from the original notes:

"Experimental tank No. 1 is fitted up as follows: A 1-inch galvanized iron pipe leads from the compressed air tank to the tank No. 1, but before entering this branches into three $\frac{1}{2}$ -in. pipes. One of these branches is carried down inside the tank and across the bottom to a dead end. The other two are carried down one side of the tank, across the bottom, up the other side and back across at the top, being connected to form complete circuits. At the bottom of the tanks the pipes are perforated and covered over with canvas. In the 1-in. air supply pipe, a $\frac{3}{8}$ -in. orifice is inserted, the difference in pressure on the two sides of which is measured by the connected water gage, and from the gage readings the consumption of air is readily calculated.

"In tank No. 2 the pump draws sewage from the bottom of the tank, thru a pipe which connects with the tank and discharges it thru a pipe leading down thru the top of the tank, and ends immediately above a galvanized iron cone, which disperses the sewage as it is discharged. An air injector is formed in the discharge pipe

just above the tank, by reducing the section area of the pipe and connecting this section of the pipe with an air orifice of $\frac{3}{8}$ -in. diameter. The difference in pressure on the two sides of this orifice is indicated by a water gage connected to the orifice pipe, and the air consumption is calculated from the gage readings.

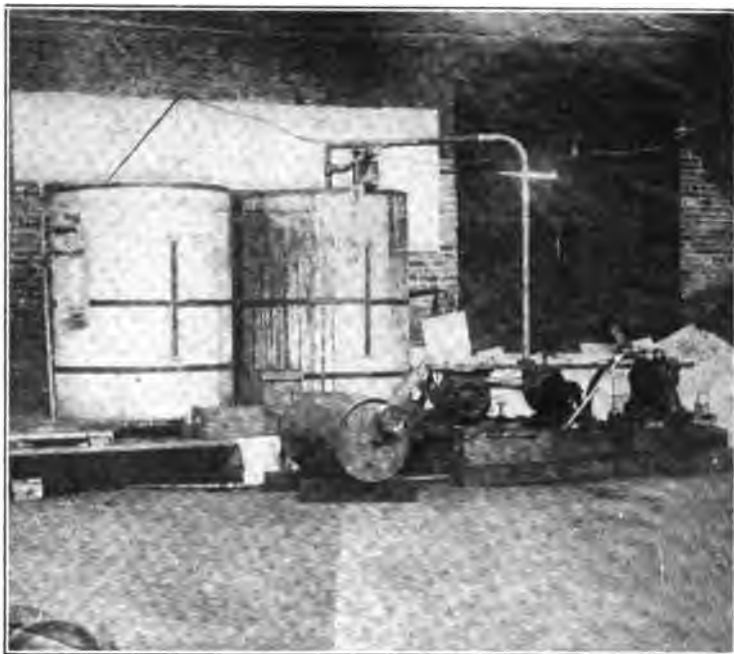
"Sewage is supplied to both tanks thru a supply pipe connected to a force main in the pump house. The effluent is siphoned from the tanks, thru a siphon installed in each tank."

Tank No. 1 was placed in operation on May 18, and tank No. 2, May 20, 1915. After a short period of operation chemical tests revealed results as shown in Table I.

TABLE I.

Performance of Tanks 1 and 2—All Quantities in Parts per 100,000.

<i>Free Ammonia.</i>	May 22-26	May 31	June 1	June 7
Raw Sewage		1.009	....	....
Tank 1	7.69	....	....	....
Tank 2	6.50	....	....	....
<i>Albuminoid Ammonia</i>				
Raw Sewage		16.03	....	....
Tank 1	2.84	....	Trace	....
Tank 2	1.026	....	Trace	....
<i>Nitrites</i>				
Raw Sewage .....		....	....	....
Tank 1	0.990	....	....	....
Tank 2	0.495	....	....	....
<i>Nitrates</i>				
Raw Sewage		0.23	....	....
Tank 1	0.485	4.32	6.72	8.20
Tank 2	0.980	8.98	8.98	8.98
<i>Oxygen Consumed</i>				
Raw Sewage .....		....	....	....
Tank 1 .....		....	0.75	....
Tank 2 .....		....	0.80	....



Regina, Sask. Showing experimental activated sludge plant.

In addition to these tests, the chemists made several observations to determine the relative amount of mineral salts, by measuring the electrical conductivity of the sewage. The average conductivity of the city water, as previously determined, was stated to be 0.0000406 (not absolute measure). The observations on the sewage showed the results given in Table II.

TABLE II.

Electrical Conductivity of the Sewage.

	Raw Sewage	Tank No. 1	Tank No. 2
May 17	0.0000432	.....	.....
May 22	435	0.0000460	0.0090509
May 24 .....	.....	464	659
May 26 .....	.....	737	903
May 27 .....	.....	940	1186

May 29	1160	1334
May 31	1165	1250
June 1	1249	1255

The difference in the results from the two tanks was due to the continued circulation of sewage in Tank No. 2, which developed greater heat than in the other tank.

TABLE III.

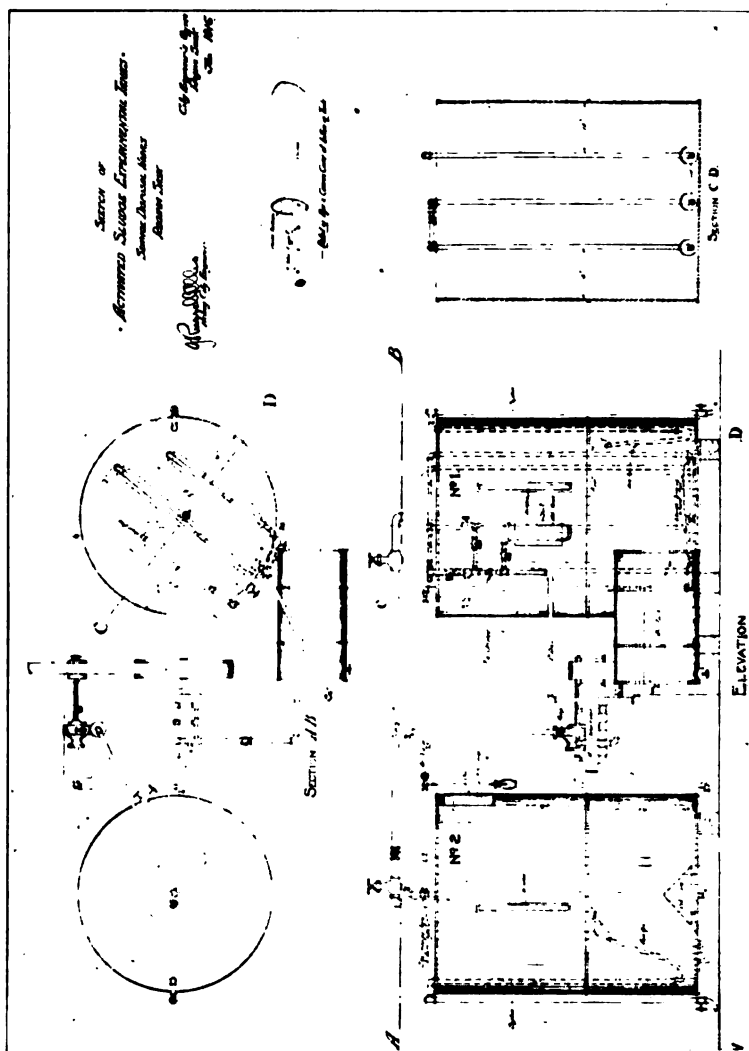
Data in Connection With the Operation of Tanks.

	Quantity of air in cu. ft. per min		Temperatures in degrees Fahrenheit		
	Tank 1	Tank 2	Air	Tank 1	Tank 2
May 18	3.96	...	55	48	...
May 19	3.60	...	56	52	...
May 20	4.40	...	66	55	58
May 21	4.40	5.08	66	57	76
May 22	4.47	5.08	69	60	84*
May 23	5.18	5.76	72	60	90
May 24	5.08	5.08	70	61	92
May 25	4.39	2.72	69	67	87**
May 26	4.90	4.07	62	67	83**
May 27	4.90	4.50	67	67	87**
May 28	5.26	4.50	64	67	87
May 29	5.26	4.70	68	68	87
May 30	4.40	4.50	73	68	86
May 31	4.70	4.30	72	68	87**
June 1	4.30	4.30	74	68	87
June 2	4.07	4.07	73	68	85

*Pail of concentrated sewage added to No. 2.

**Pail of concentrated sewage added to each.

When the fresh sewage was added to the tanks, it was transmuted into odorless matters in a very short time. The sewage first turned clear with a black sediment having a mossy odor, and later became brownish in color with a light brown sediment. When this stage was reached the sewage was found to be stable and non-putrescible.



After the foregoing series of tests, the experimental plant was transferred to the sewage disposal works, and re-erected in the pump house there. It was then operated by the regular attendants, the tanks being filled and drawn during cycles of about six hours. This was continued for several months, and the results appeared to be highly satisfactory.

Near the end of the year, it became necessary to re-arrange the apparatus and change the motor driving the pump and air compressor. After this lapse the tanks were cleaned out and the experiments started again. Beginning on January 12, 1916, operation was begun on a 12-hour cycle, i. e., 10 hours for aeration and 2 hours for settling, drawing and filling. It was planned to gradually reduce this time as the sludge deposit purification was found. The air pressures, volumes of sewage treated, temperatures of sewage before and after each filling, and the room temperature, were recorded. During January and February, the room temperature ranged from 38 degrees to 46 degrees; the temperature of the fresh sewage entering the tanks, from 46 degrees to 50 degrees; and the temperature after aeration, from 40 degrees to 47 degrees; showing an average loss of 7 degrees in Tank No. 1, and 6.3 degrees in Tank No. 2, during the aeration period.

The tanks were operated continuously from January 12 to February 15, being then closed down till February 20 for repairs to pump and motor. Tank No. 1 was in operation from February 20 to March 2, and Tank No. 2 from February 20 to February 25. Both tanks were operated from March 13 to April 24, from April 27 to May 5, and from May 13 to June 5. The idle periods were due to the adjustments and repairs required by the apparatus. The time of the staff during the summer has been entirely taken up with the press of the summer work. On April 5, the cycle was reduced from 12 hours to 10 hours.

<i>Relative Stability in Days:</i>		Tank No. 1	Tank No. 2
February	5	4	3.9
February	12	10	3.2
February	29	5.3	..
March	2	3.3	..
March	14	1.9	2.0
March	15	5.0	2.7
April	1 .....	..	1.7
April	17	2.6	2.6
April	18	2.8	2.8

The size of the plant has not warranted an attempt to determine

the cost of operation. The idea in starting was, as set out above, to obtain data on the adaptability of the process, after which a request might be made for an appropriation to build a plant on a sufficient scale to represent the final layout of the plant which would be required to take care of the sewage from the entire city. The results now indicate that the process is adaptable to our local conditions, and consideration is being given to the design of a large-scale unit.

The experiments were instituted by Mr. R. O. Wynne-Roberts, the City's Consulting Engineer, and conducted by him up to June 1, 1915. Mr. Wynne-Roberts was assisted by Messrs. Andrew and Cruikshanks, chemists. During June and July, 1915, the work was in charge of Mr. F. McArthur, City Engineer, and since August 1, 1915, has been handled by Mr. J. Russell Ellis, Acting City Engineer, assisted by Mr. D. A. R. McCannell, Assistant Sewerage Engineer.

G. L. NOBLE, Assistant Superintendent, Armour & Company, Chicago, Ill., (by letter to Mr. Hammond, dated Sept. 18, 1916): We are operating our experimental Fort Worth, Texas, plant continuously at the present time at the rate of 60 gallons per minute. We send you a photograph of the plant. On account of the protecting roof, we are sorry we are unable to show the surface agitation. However, this distribution of air is very good indeed.

At this plant we are using 1-32-in. holes instead of 1-25 in., and are using a water seal to keep them from clogging.

At the Chicago experimental plant, Mr. Noble states that later experiments show, instead of 50,000 gallons, about 25,000 to 30,000 gallons of sludge per million gallons of sewage, which will give about $1\frac{1}{4}$ tons of sludge dried to 10 per cent. moisture.

This is less than we at first anticipated, owing to the fact that we got a better settling sludge after we learned how to operate the plant more perfectly. Our Chicago plant has been dismantled since the larger plant at Fort Worth was started.

WILLIAM R. COPELAND, Chief Chemist, Milwaukee Sewerage Commission, (by letter to Mr. Hammond): I have read your excellent article on "Sewage Treatment by Aeration and Activa-

tion," in the advance papers, and have but few comments to offer.

On page 355 you speak of the fact that you did not think that the operation of the Worthington press was very successful last winter. We have made a considerable advance with the operation of the press since then, so that now we discharge 1,400 to 1,500 lbs. of cake pressed to 75 per cent. moisture at an operation. This can be increased by placing more sacks in the press, until I feel sure that one press can be made to deliver 8,000 lbs. of 75 per cent. moisture cakes in twenty-four hours. On the basis of \$2.50 per unit of nitrogen, our sludge is worth \$12.50 per ton of dry material.

CARL H. NORDELL, Engineer of Design, Milwaukee Sewerage Commission, (by letter to Mr. Hammond): I have read your paper with much interest. It contains a great deal of valuable information as to what is being done in activated sludge. On the subject of air diffusion, I realize that any increased efficiency is dependent upon keeping the plates clean, both on the top and on the bottom, and as we have at present working-size experiments underway to determine these points, I feel that discussion might well be postponed until their outcome is known.

Mr. Nordell is also experimenting with a new material for producing a very fine bubble. It is bass-wood cut across the grain. A very fine bubble is produced with much less loss of head from friction, and apparently with less tendency to clog than the porous disc material that has been extensively used. It is also a more lasting material.

T. CHALKLEY HATTON, Chief Engineer, Milwaukee Sewerage Commission, supplies the following data in addition to those already included in Mr. Hammond's paper, (by letter): We have been cleaning out eight aerating circular tanks in our large plant, and much to our surprise have found some filtros plates which have shown signs of disintegration on the face exposed to the sewage, and no disintegration on the face exposed to the air.

This disintegration is of such a character that you can rub the sand particles off with your fingers, the cementing qualities having become negligible. This is only true in spots upon the plates

and not thruout the whole plate. The bottom of the plate for perhaps 25 per cent. of its area has become non-porous thru carbonized oil and dust carried thru the filter into the distributing air pipes; but this, I think, we can entirely overcome by filtering our air thru cloth, and being more careful about oiling our blowers—the latter operation having been done in the past without any thought of oil getting inside the blower.

WILLIAM T. CARPENTER, Brooklyn Sewage Disposal Experimental Station, (by letter): Mr. Hammond's paper seems to cover with considerable thoroness the knowledge we possess on the subject of activated sludge. I have been specially interested in what Mr. Hammond says about aeration as a means of sludge disposal, as well as in Mr. Eddy's paper before this meeting on the subject of the digestion of activated sludge. I remember speaking of the possibility of some such action in a paper on the subject of activated sludge before the Sanitary Engineering Section of the American Public Health Association last autumn. The studies on the subject during the summer of 1915 convinced me that sludge was disappearing somewhere. During the summer just closed, we applied air to a mixture of digested Imhoff tank sludge and water, containing 9,000 parts per million suspended solids.

After about a month's aeration I was surprised to find that the suspended solids content of the mixture had fallen to about 10 per cent. of its original value. Our sprinkling filter results seem to indicate, when considered as a whole, that a certain amount of digestion takes place in the body of filter. We have been in the habit of regarding sludge digestion as something of an exclusively anaerobic nature, and anaerobic action seems much more prone to nuisance than does aerobic action. It would seem, then, that sludge destruction in the presence of artificially applied air offers a not unpromising field for study. There is the question of cost to be considered, but there are many circumstances imaginable where the loss of property values due to offensive conditions would warrant a considerable expenditure for air, if thereby the nuisance could be abated.

W. L. STEVENSON, Assistant Engineer, Sewage Disposal, Philadelphia, Pa., (by letter): The activated sludge treatment

of sewage has been under investigation for a long enough time and in sufficiently large-size units to show clearly some of its advantages over other methods of treatment and also to indicate some difficulties not yet overcome.

Among the former may be mentioned freedom from odor during aeration even while treating a crude sewage that is quite offensive, the clarity of the final effluent, and the relatively small area required for the works.

From the practical point of operation, the disposal of sludge is usually the most difficult and troublesome work at any sewage treatment plant.

Mr. Hammond states, in his excellent paper, that from 15 to 30 cubic yards of watery sludge may be expected from each million gallons of sewage treated by the activated sludge process.

Continuing he says "we do not doubt that it may be gotten rid of, but how?" From what the writer has seen and read, this difficulty arises from:

- (a) The relatively large volume of sludge;
- (b) Its high moisture content;
- (c) Its exceedingly putrescent nature.

The large volume is probably due to the complete removal of all suspended and colloidal matter from the sewage and to the high moisture content of the sludge.

It is possible that the high putrescibility may be overcome by continued separate aeration, as has been done at Cleveland.

Confining attention to sewage treatment works of large capacity, the writer believes that in nearly all cases such works should be designed so that they may be constructed progressively, so as to yield progressive degrees of treatment before discharge of the effluent into the receiving body of water.

This may be accomplished at present by the use of

- (a) Screens;
- (b) Sedimentation in Emscher tanks;

- (c) Oxidation in trickling filters;
- (d) Resettlement;
- (e) Disinfection or intermittent filtration.

The utilization of dilution and the deferring of the higher degree of treatment until demanded by increased population or requirements of the receiving body of water are economic necessities.

In the adoption at first of the activated sludge treatment of sewage, this progressive idea is abandoned, for by that process crude sewage is rendered clear, stable and partially disinfected.

Mr. Hammond considers $\frac{1}{8}$ -in. or $\frac{1}{4}$ -in. screening desirable to precede the aeration tank and quotes Mr. Frank, who shows that, in certain experiments, while crude sewage produced 1 volume of excess activated sludge per 104 volumes of sewage, settled sewage produced only 1 volume per 525 volumes of sewage.

The writer is of the opinion, therefore, that where a high degree of treatment is not immediately required it is a grave mistake to only give consideration to the activated sludge process, which should be considered as a finishing process.

The efficiency of the Emscher tank, when properly designed and operated, to remove and digest the settleable solids from sewage and so produce the minimum amount of inoffensive sludge, has been clearly demonstrated in both America and Europe.

But the effluent from these tanks is turbid, putrescent and pathogenic.

If, then, activated sludge treatment be relegated to a finishing process, we will obtain the preliminary removal of suspended matter evidently needed; the amount of air used and sludge produced reduced in the aeration tanks and the progressive construction of the works will be made possible.

The combination of the Emscher tank for preliminary treatment and the activated sludge process for finishing treatment may also solve the aforesaid difficulties of the excess activated sludge; for if it be discharged into the crude sewage and the slopes of the settling compartment made steeper and the sludge compartment made larger

than usual in Emscher tank design, the only sludge from the entire plant will be that drawn from the Emscher tank.

No trouble should be caused by the introduction of the aerobic activated sludge into the anaerobic sludge chamber of the Emscher tank because activated sludge so rapidly putrefies when not kept in an aerated state.

EXPERIENCE AND RESULTS OF FOUR YEARS OPERATION OF COARSE SCREENS, GRIT CHAMBERS, IMHOFF TANKS AND TRICKLING FILTERS, AT ATLANTA, GEORGIA.

By Charles C. Hommon, Chemist and Bacteriologist in Charge.

The City of Atlanta is peculiarly situated in that it is located on the crest of a ridge that divides the drainage area of northwest Georgia, part of the city's drainage going into the Gulf of Mexico and the remainder into the Atlantic Ocean. At present the population is about 200,000 with a large variety of manufacturing industries. In the beginning Atlanta was not unlike a great many other cities, in that it followed the line of least resistance and disposed of its sewage by discharging it into the nearest and most available water course. There are three creeks in the vicinity of Atlanta that virtually have their head waters within the city limits, and it was the general practice, prior to 1912, to discharge all sewage, which was collected in the combined type of sewers, into these so-called creeks, which became little more than open sewers. During the hot summer months these creeks became very objectionable, and law suits accumulated against the city to have the nuisance abated. It was very evident that the only way to secure relief was to properly treat the sewage in some manner before it was turned into the creeks, but the early methods of sewage treatment that were in use in this country were very expensive, and not always satisfactory.

On the recommendation of Dr. Rudolph Hering, former consulting engineer for the city, and Capt. R. M. Clayton, city engineer, three sewage plants were designed and built, using the newly developed two-story Imhoff settling tanks, and it is the purpose of this paper to report as concisely as possible the facts of interest that have been learned in the past four years from the operation of these plants.

Intercepting sewers deliver the sewage from the trunk outfalls to the three plants, the location of which, affords operation by

gravity, thus saving the cost of pumping. The three plants are known as the Proctor Creek, Peachtree Creek and Intrenchment Creek plants. Their capacities are 3,000,000, 8,000,000 and 5,000,000 gallons respectively, and they were placed in service on the following dates: August, 1912; September, 1913, and June, 1914.

The equipment of all three plants was substantially the same and consisted of coarse grate bars, grit chambers, Imhoff tanks, fine screens, or roughing filters and trickling filters.

Coarse Screens.

The coarse screens, or grate bars, thru which the raw sewage passes on entering the plants, are of $\frac{1}{4}$ -inch flat bar iron, spaced $1\frac{1}{4}$ -inches, center to center, and laid at an angle of 45 degrees down stream. They have been very effective in removing from the raw sewage all floating material, such as dead animals, pieces of wood, tin cans, rags, etc., that might cause trouble if allowed to pass into the Imhoff tanks. The amount of screenings collected varies considerably in quantity, due to the fluctuations of rainfall and seasonal changes. There is always more after a heavy rain, the amount averaging (daily), about 30 pounds wet per million gallons. As soon as collected the screenings are hauled away and buried, so as not to allow them to decay and create a nuisance.

Grit Chambers.

The grit chambers have done and are doing very creditable work in removing sand and grit from the raw sewage. The retention period of the sewage in the grit chambers is about 30 seconds, and with this period there is only a comparatively small amount of organic matter deposited with the sand. The sand dump-pile has never been offensive, even in the warmest weather. Sand that is needed for the resurfacing of the sludge drying beds is taken from this dump, without washing. During 1915 the Peachtree Creek plant grit chambers, collected an average of 0.6 cu. yd. of sand per million gallons, and the cost of removal was 14 cents per cu. yd., labor costing 15 cents per hour. The sand deposited at the other plants ran considerably less, averaging about 0.2 cu. yd. per million gallons, and the cost of handling averaged about the same as the Peachtree plants.

Imhoff Tanks.

The Imhoff tanks are of the circular type, 24.5 feet deep, arranged in series of three, designed so as to give the sewage in the settling chambers a retention period of three hours, and are provided with crossover channels for reversing the flow. The tanks at all three plants have done excellent work, removing practically all of the settleable solids, and from 60 to 85 per cent. of the total solids.

I. AVERAGE YEARLY REMOVAL OF SUSPENDED SOLIDS BY IMHOFF TANKS, PARTS PER MILLION.

	1913			1914			1915		
	Total.	Removed.	%	Total.	Removed.	%	Total.	Removed.	%
Peachtree Crk.	109	54	49.5	120	62	51.6	145	86	59.3
Proctor Crk.	238	182	76.5	402	338	84.0	328	282	85.9
Intrinchment Cr. ...	...	...	...	...	...	...	140	96	68.5

The greater efficiency of the Proctor Creek tanks, over that at the other two plants is due largely to the reaction of the salts of calcium and iron, from industrial wastes, whereby a flocculent precipitate is formed that assists in precipitating the colloids.

Distribution of Sludge in Sludge Wells.

As stated above, the tanks are arranged in series of threes and, as the result of this arrangement, one disadvantage stands out very prominently, namely, the unevenness of the deposit in the sludge wells. Apparently the bulk of the settleable solids is deposited in the first hour of retention, or while the sewage is passing thru the first chamber, consequently the sludge-well of the first tank receives more than its proportionate share of the settled solids, and the third well gets less. By reversing the flow at proper intervals, the sludge level can be kept fairly constant in the two end wells, but this method of operation has little or no effect on the amount of material deposited in the middle compartment. As a result of this uneven distribution the end sludge-wells are compelled to perform the work that should be done by the middle section, and the sludge-storage period is thereby reduced. Thus far, however, this decrease in storage capacity of the sludge-wells has not caused trouble at any of the plants, as the sludge from the end tanks has always been of a good quality. With good weather conditions it dries into good spadable material in from seven to nine days, if

the sludge is not put on the sludge beds more than 8 inches deep. Recently the city closed a contract in which a local concern agreed to pay 15 cents per cu. yd. for the accumulated sludge, and to take the annual output at the same rate, from the beds. It costs approximately 15 cents per cu. yd. to remove the sludge from the beds, thus making a net return to the city of 30 cents per cu. yd. It is understood that the purchaser contemplates using it as a filler for commercial fertilizer.

II. AVERAGE ANALYSIS OF 36 SAMPLES OF SLUDGE COLLECTED FROM IMHOFF TANKS, ATLANTA, GEORGIA.

Specific Gravity	Per cent. Water	Per cent. Volatile	Per cent. Mixed	Per cent. Nitrogen	Per cent. Ether Sol. Fat
1.02	87.05	39.1	60.9	1.25	6.11

Formation of Foam and Scum in Gas Vents.

The accumulation of scum in the gas vents seems to be a rather serious draw back of the Imhoff tanks in many places where they are in use, and we have had some trouble of this nature in Atlanta plants. Our first trouble was with the gas vents foaming or boiling over during the ripening period. The gases rising from the sludge well were encased in a greasy, tenacious film that did not burst readily, and the vents became filled with bubbles and foam and eventually overflowed into the settling compartments of the tanks. Spraying the vents with water under pressure was very effective for the time being, but they soon filled again. The free-board was extended on one vent 8 feet above the level of the sewage in the settling chambers, but in less than twenty-four hours the foam ran over the top and apparently would have gone higher, so this scheme was abandoned. Finally we resorted to drawing practically all of the sludge from the wells and starting anew, and in a second trial the trouble did not appear to any extent. At the time the foaming was most troublesome at the Proctor Creek plant, the Intrenchment Creek plant was under construction, and it was thought advisable to enlarge the gas vents with a view to eliminating the above trouble. The central vents were made twice as large, increasing the total vent area by 33 per cent. During the ripening period at this plant the foaming was very troublesome and lasted for about six weeks. The larger vents seemingly had no beneficial effect in preventing the formation of foam.

On comparing the results of the larger vents with those of the

smaller ones a rather interesting fact is noticed that the writer thinks worthy of consideration and further thought. In the case of the larger vents there has always been a heavy scum, sometimes as much as 4 feet thick, while the smaller vents remained comparatively free. It is also true that even in the case of the smaller vents of the middle and furthest tanks from the inlet, where the gas effervescence is less violent, the accumulation of scum is greater than in the vents of the inlet tanks. In other words, where fermentation is most active, there is the least accumulation of scum. It is also noticeable to a degree that more scum collects in the winter months in all of the vents than in the summer months, when the gas production is greatest. It is the writer's opinion that the mechanical agitation due to the gas bubbles tends to break up the scum and release the gas entrained in it, thus allowing the floating matter to sink to the bottom. If this assumption is true, it appears that the smaller gas vent has a distinct advantage over the larger, in that it tends to make the gas ebullition more effective in breaking up the scum.

Utilization of the Gas Liberated from Imhoff Tanks.

Utilization of the gas liberated from the Imhoff tanks has been in practice almost a year at the Peachtree Creek plant, and has proven to be very practical as well as a financial success to the city. At present the gas is being used for all purposes in the laboratory, and for heating and cooking in the writer's residence. It is hoped that in the near future sufficient funds will be obtained for installing an exterior lighting system around the plant. Assuming that all the vents of the thirty tanks at Peachtree Creek are giving off gas at the same rate as from two we are now using, the whole plant is producing 30,000 cubic feet per day, or 3,750 cubic feet per million gallons of sewage treated. The volume of gas produced seems to be quite variable, due principally to temperature changes, and the method of operating the tanks also seems to have a marked effect on the gas production. There is always a noticeable decrease just after drawing sludge.

III. ANALYSIS OF GAS FROM IMHOFF TANKS.

Source		Carbon					B.t.u.
		Methane	Nitrogen	Dioxide	Oxygen	Hydrogen	
Tank	nearest inlet....	72.5	5.7	2.6	0.0	19.2	832.9
Tank	nearest outlet...	50.6	4.6	31.0	0.0	13.8	586.9

Fine Screens and Roughing Filters.

It was thought at the time the plants were designed that it would be advisable to pass the tank effluent thru a fine screen, or roughing filter, before admitting it to the filter beds, and a Weand revolving self-cleansing screen was installed at the Proctor Creek plant, and roughing filters at the other two plants. The writer operated both devices, but found that they did not remove sufficient material to warrant their maintenance, so their use was discontinued. There is practically no material in the tank effluent that can be economically removed by fine screens or roughing filters, and it is the writer's opinion that with sewage similar to Atlanta's it is not necessary to screen the effluent from properly working Imhoff tanks before applying to trickling filters.

Filter Beds.

The filter beds have done exceptionally good work, considering the overloading they have been subjected to, when comparing them to current practice. The Proctor Creek plant is provided with 1.5 acres of filtering area, and was originally designed to handle 20,000 people per acre, but the bed is actually operating 100 per cent. overload. This overloading is caused by the discharge of night soil from surface closets in the city, into the Proctor Creek interceptor. By referring to Table IV it can be seen, however, that the effluent from the filter beds is of a very good quality.

The Peachtree plant is provided with 2.5 acres of filter beds, and there are approximately 80,000 people contributing to the plant. A part of the tank effluent is by-passed around the filters, however, and the beds are handling approximately 25,000 people per acre.

The Intrenchment Creek plant has 2 acres of filter beds, and there are 50,000 people contributing to this plant, thus making 25,000 people to the acre.

Generally speaking, the beds at all three plants have remained in first-class condition, with the exception of the early spring of 1915. During the winter of that year there developed a very heavy growth of algae on the Peachtree Creek beds, and in the early spring, when it began to die and sluff off, the beds showed serious evidence of

clogging. Finally the algae had to be picked off by hand. (See *Engineering Record*, Sept. 11, 1915, vol. 72). After removing the algae, the beds unloaded properly and were soon in excellent condition.

IV. TABLE GIVING YEARLY AVERAGES OF RESULTS ON ANALYSIS OF TANK AND FILTER EFFLUENTS AT THE THREE DISPOSAL PLANTS AT ATLANTA, GEORGIA.

	Free Ammonia		Organic Nitrogen		Nitrites & % Nitrates		Sat. Dis. Oxygen		Relative Stability	
	Tank Eff.	Filter Eff.	Tank Eff.	Filter Eff.	Tank Eff.	Filter Eff.	Tank Eff.	Filter Eff.	Tank Eff.	Filter Eff.
1913										
Peachtree	11.4	6.3	5.8	2.7	0.3	5.9	13	78	39	
Proctor	20.0	9.9	9.0	3.3	2.2	3.3	33	64	96	
1914										
Peachtree	11.5	4.4	5.2	2.9	0.4	6.5	9	69	97	
Proctor	25.4	13.8	8.0	4.9	1.9	3.9	40	67	97	
1915										
Peachtree	10.1	3.5	6.1	3.0	0.6	6.7	6	63	98	
Proctor	20.6	7.9	4.6	2.3	2.3	2.7	..	..	98	
Intranchment ..	11.7	4.3	7.1	3.6	0.4	5.6	..	..	97	

Ventilators on Filter Beds.

Several experiments have been made, from time to time, to prove the value of ventilators in the filter beds, but so far as could be determined they did not accomplish a great deal, and it is the writer's opinion that the results do not warrant the expense of putting them in.

Sludge Drying Beds.

The sludge drying beds are under-drained by 3-in. tile spaced 7-ft. apart and laid on a well-rammed clay bottom. The lower 10-in. of filtering material is of 1.5-in. crushed stone gradually grading to 1/4-in. material with a thin layer of sand on top. The surface of the Proctor Creek beds was made level while the Peachtree and Intranchment Creek beds were put on a slope of 1-ft. to 100-ft. to facilitate the distribution of the sludge. The thickest sludge the Atlanta plants have ever produced contained 79 per cent. water, and no difficulty was experienced in getting this sludge deposited on the level bed in an even layer. This being true, it necessarily follows that it is impossible to get an even deposit on the sloping beds. This is undesirable in that it causes uneven drying of the sludge, and thus reduces the capacity of the bed.

The net area of the Proctor Creek beds is 9,030 sq. ft., and

was intended to handle the sludge from 30,000 people, allowing 0.30 sq. ft. per person, but in addition to this normal load the night soil from approximately 30,000 more people from all sections of the city is discharged into this sewer. As a result of this overloading, only about 30 per cent. of the sludge is dried on the beds. The remainder is run direct from the tanks onto lowlands surrounding the beds and allowed to dry.

The net area of the Peachtree Creek beds is 17,200 sq. ft., and the contributing population 80,000, thus allowing 0.22 sq. ft. per person. The area is entirely inadequate, and a good portion of the sludge at this plant also has to be dried on surrounding lowlands.

The net area of the Intrenchment Creek beds is also 17,200 sq. ft., and the contributing population 50,000, making 0.34 sq. ft. per person. These are the only beds that furnish adequate drying area. By careful manipulation and removing the sludge as soon as it is dry we have been able to dry all the sludge from this plant on the available sludge drying area.

Odors.

Very close observations have been made to determine the effect the plants have on the surrounding neighborhood, and the condition of the creeks below the entrance of treated sewage. The writer has never detected any noticeable odor, except in the immediate vicinity of the plant, and to his knowledge there has never been any complaint made against the plant, all remarks being of approval rather than condemnation.

Cost of Operation.

The average cost of operating the three sewage plants during the year 1915 was \$1.93 per million gallons treated, or 7c per capita, assuming a contributory population of 160,000. This figure, however, only includes actual operating expenses, such as supervision, labor, renewals, supplies, water and electricity, and does not include interest on investment or depreciation.

DISCUSSION.

EZRA WHITMAN (by letter): The writer has read with a

great deal of interest the paper of Mr. Hommon, giving his experiences with the Imhoff tanks in Atlanta. During the winter of 1914-1915 I was in Atlanta and saw the Peachtree Creek and the Proctor Creek plants in operation, and the results secured by the tanks as demonstrated by a physical examination were the most satisfactory of any of a dozen or more Imhoff tank installations the writer has seen.

One of the first, if not the first, Imhoff tank to be constructed in this country was built at the Walbrook testing station, Baltimore, Md., in 1910. This tank had to deal with a very fresh sewage, the maximum time for the sewage flow to reach the plant from the farthest house being considerably less than an hour. The population contributing to this plant was approximately 1,800 people, and the sewage was entirely domestic, there being nothing but residences and a few grocery and drug stores connected to the sewers. A thick scum formed in the gas vents of the tank and during the entire period of operation of this tank continued to form. It was periodically removed by a man with a large scoop and was buried in the ground.

At another plant near Baltimore, built for the Roland Park Company, the scum formed so thick in the gas vents that it had to be removed, and for a number of months an iron cart was used in removing this scum and carrying it to a place where it could be buried without offense. This scum gradually ceased to form on the tank at the Roland Park Company, and at the present time this tank is working without any difficulties from the scum in the gas vents.

In the new Imhoff tanks built for the main sewage disposal works for Baltimore there has been a great deal of difficulty in getting the tanks in proper working order. The gas vents have boiled over time and again, and there has been a great deal of difficulty encountered with the formation of scum in the settling compartment of the Imhoff tanks. In trying to draw off the sludge from one of the tanks, and give it an entirely fresh start, it was found that nothing but liquid ran from the sludge pipe, showing that the entire sludge deposited in the tank had risen in the shape of a scum which was a number of feet thick. The difficulties at this plant are probably due to the fact that the sewage before reaching the tanks has passed thru a long outfall sewer in which septic action has started,

so that the sewage is thoroly septic by the time it reaches the Imhoff tanks.

At Rockville, Md., the writer constructed an Imhoff tank and the sewerage system which contributed to it. The connections to the sewers were made very slowly, covering a period of over a year, and the consequence was that the tank was operated with a very small quantity of sewage at the beginning, and this quantity was gradually increased. Under these conditions no trouble whatever was encountered with the forming or excessive accumulation of scum in the gas vents. I have also visited other cities where similar results were obtained, and it would seem that the best method of bringing about the proper operation of the Imhoff tank is to begin by passing small quantities of sewage thru the tank, gradually increasing the amount at such a rate as will keep down the excessive formation of scum.

THE NUISANCE ASPECT OF MUNICIPAL PLANTS FOR THE DISPOSAL OF SOLID AND LIQUID WASTES.

By George W. Fuller, Consulting Engineer, New York City.

Excellent papers in the field of sewage disposal and on the collection and disposal of garbage and other municipal wastes have been presented before this Society in previous years. An inspection of this year's program shows that again the Society will hear of the latest developments concerning activated sludge and other methods of handling municipal wastes.

This short paper is not intended to deal specifically with the longgoings and shortcomings of various types of works in the field of municipal sanitation. A broader and more general viewpoint is held with respect to the nuisance question and a few comments are offered in the hope of promoting a discussion of the circumstances that still cause many citizens to view sewage disposal and refuse disposal plants as nuisances. It is hoped that a clearer understanding may be reached as to why waste products in this country are not disposed of in a more sanitary and efficient manner.

The general discussion of this branch of municipal sanitation seems appropriate at a time and in a district where grave concern for several months has been felt as a result of an unusual prevalence of infantile paralysis. It is fitting to discuss nuisances from municipal wastes in a city where the garbage problem has not yet been satisfactorily solved, altho it has been carefully studied and reported upon from time to time in earlier years. The topic is timely in districts where the highly polluted Passaic River, with its offensive odors, has been a characteristic for some 20 years, and with corrective works not yet completed. Coming with these corrective works have been various differences of viewpoints, not only in the Passaic Valley sewerage district itself, but also without the district, as the project being executed has received protests from New York City and State, who have sought to enjoin the carrying out of the works thru a pending suit before the United States Supreme Court.

In various communities in this vicinity private scavengers, altho perhaps giving a service thoroly proportionate to the money received by them, are regarded with feelings of marked uncertainty as to the adequateness of their service from a sanitary standpoint. This refers to the means taken both for the collection and the disposal of garbage, refuse, and other household wastes. Unsanitary conditions prevail at many of the dumping places, and no one can tell the distance from the dumps to which flies, following foul collecting wagons, may transport infected material to households conducted in a thoroly sanitary way.

The city of Paterson, with a population of about 140,000 people, is operating a 60-ton modern destructor plant for the disposal of its garbage, with results quite displeasing to the citizens resident in the vicinity of the plant. Garbage collections are unsatisfactory and are being readjusted on the basis of using motor trucks. The destructor plant is of modern design, but it is grossly overloaded and has no reserve units in the event of accidents to the mechanical devices. In many respects the type of plant resembles the destructor at Savannah, where, as Mr. Conant described to this Society last year, a city of 80,000 population secures satisfactory and efficient results from a plant of a capacity rated as 130 tons daily.

On Staten Island there are destructor plants resembling in type that at Paterson. They are of ample capacity for the work they do, and are carefully operated. No nuisance has arisen so far as known in a community that has most vigorously protested against the installation of a new garbage reduction plant by a contractor who is to dispose of garbage from other portions of the City of New York.

This is a section of the country in which there is a relatively large number of fairly small sewage treatment plants. Most of them have been operated with a fair degree of success, and so far as known, no injunction suits have been issued to restrain their operation or to compel extensions or betterments. And yet it is an unquestionable fact that it is becoming more and more difficult to secure sites in this district for sewage treatment plants. In the Plainfield district the population has increased during the past 20 years so as to have outgrown two sewage disposal plants, built in three installations. The present overtaxed plant is situated within

the city limits and urgently requires relief. Such new works on a rather unusually well isolated site some $2\frac{1}{2}$ miles farther down the valley are now approaching completion, and at the time facing an injunction suit whereby a property owner some 2,000 feet distant from the new plant seeks to enjoin the operation of the works.

WHAT ARE NUISANCES.

Nuisances are conveniently grouped under the two headings, namely, those which threaten the public health, and those which create personal discomfort thru smell, soot, unsightly conditions, and the like. Perhaps mention should be made also of another aspect encountered by plants for the disposal of municipal waste, and that is the sentimental objection held by property owners on account of having these waste plants located anywhere near their habitations. This latter feature is based on the contingency in part of assumed neglect in the proper operation and upkeep of existing plants elsewhere, and is an item to be reckoned with.

NEED FOR IMPROVEMENT.

Sufficient has been said in the above outline as to sanitary works in this section of the country to recall to the mind of most of the members of this Society more or less similar conditions in districts elsewhere and with which they are familiar. Further details are unnecessary to portray an unsatisfactory situation wellknown to sanitary engineers, but which will never be materially corrected without more earnest support and co-operation from the American public than generally exists today. Fortunately there are some exceptions to this rule, and it is hoped that discussions may lead to steps by which these exceptions may be made more numerous and may be more generally understood and appreciated.

REMEDIAL CONSIDERATIONS.

The first theme to be offered for your consideration is the general statement that sanitary engineering as an art is sufficiently well understood by experienced engineers so that the nuisance aspect of municipal waste problem can be kept satisfactorily under control. For them to do so it is necessary to receive the proper authorization for investigation and report on the local conditions and to have

their recommendations adopted with the outlay of necessary funds for purposes of proper construction and of efficient operation and upkeep. It is believed that it is unnecessary in this paper further to speak of what is capable of execution under favorable conditions by engineers in the field of sewage treatment or in the collection and disposal of various solid wastes. That subject is well handled in other papers appearing in the Proceedings of the Society.

The second theme suggested for the consideration of this meeting is that the actual standing or status of the art of sanitary works in point of adequacy and efficiency bears a relation, as a general proposition, to the prevailing mass view, or average opinion, of the general public. At a time when the public mind is agitated and perhaps in a measure legitimately frightened by the lack of proper sanitary conditions, it is probable that it would not be difficult to receive the endorsement of a majority of citizens of such corrective measures as may be necessary. But with the advent of cold weather and the passing from the public mind of the force of a spreading epidemic, it seems unfortunately true that corrective sanitary measures likewise fall from view. If this attitude is correct, as the writer believes is a fact, then it becomes necessary to look for still additional facts and conditions, if we are really to face conditions as they are and strive for corrective measures.

The third theme for consideration seems to be the availability of funds for sanitary works in communities where, by custom and in a measure by law, there is naturally and properly a restriction in the amount of public funds that may be expended for public works, sanitary or otherwise.

In a recent report of the United States Bureau of Census on the financial statistics of cities are figures showing the relative cost of those measures which tend to promote cleanliness, and which are classed under the general term sanitation, and other measures which more directly affect the health of the people. These tabulated data show that, excepting a few of the largest cities, less than \$2 per capita per annum is usually spent for measures which affect the public health indirectly, such as sewers, street cleaning, and garbage disposal, and for those which are directly influential in controlling disease (Health Department). If we consider the av-

erage of the cities of the country which have populations higher than 30,000, we find that the cost of sanitation amounts on an average to only \$1.42 per capita per year, while the expenses for health conservation amount to only \$0.35 per capita per year.

COST PER CAPITA.

Group.	No. of Cities in Group.	Population.	Sanitation or the Promotion of Cleanliness.	Per Cent. of Total Municipal Costs.		
				Conservation of Health.	Sanitation.	Conservation of Health.
I	9	500,000 and over	\$1.75	\$0.44	8.2	2.1
II	9	300,000 to 500,000	1.51	0.41	7.5	2.1
III	33	100,000 to 300,000	1.25	0.29	8.8	2.0
IV	57	50,000 to 100,000	1.02	0.24	8.4	2.0
V	82	30,000 to 50,000	0.84	0.19	7.2	1.6
All cities.	195	500,000 to 30,000	1.42	0.35	8.2	2.0

The figures in this table show that the per capita expenses of both sanitation and health conservation increase considerably as cities become larger, but that the percentages which these expenses are of the total municipal expenses remain practically constant for all cities whatever their size, averaging 8 per cent for sanitation and 2 per cent for health conservation.

Small cities and towns frequently and perhaps as a rule spend much less than the sums above given and of course receive proportionately less service.

The question arises, "Has not the time come when there should be a reconsideration of what is fair and reasonable for a community to spend for sanitation in various ways, in order that the interests of the public are truly served to best advantage?"

FREEDOM FROM NUISANCE IS PURCHASABLE.

For several years the reorganized State Department of Health of New York has proceeded on the basis that "The public health is purchasable within certain limits."

It is equally true to say that freedom from nuisances as regards the disposal of solid and liquid wastes of a municipality is also purchasable within certain limits.

Now the question arises whether these types of works have re-

ceived adequate consideration in the past. The matter should be discussed to a logical conclusion, both separately and in conjunction with the need of new roads, new bridges, new city halls, parks, playgrounds, and various other ways of expending the public funds, as clearly pointed out by Capt. Norton last year before this Society.

But regardless of the conveniences of modern street surfacing, has not the recent epidemic of infantile paralysis in the New York district and vicinity shown that it is highly important that garbage and rubbish be collected and disposed of in a way that does not conduce to ready opportunities for the transmission of infectious diseases?

Has not the time arrived when the uncovered garbage dump should become a thing of the past?

Has not the lesson been sufficiently learned that unsewered districts with open privies, and the transmission by flies of infected material from one section of a city to another, are a sufficient menace to all residents of the community, so that this also should be corrected without delay?

Surely there can be no argument strong enough to assail seriously the proposition that all branches of municipal service, as relates both to the collection and the disposal of liquid and solid wastes, should be placed on such a basis that no sanitary dangers are imminent in any section of a community.

It is believed that there is only one safe and sane answer to this proposition as regards its strictly sanitary aspects. City planning must provide for adequate works as needed. Their cost for construction and operation is not a suitable topic for discussion here, but it is sufficient to say that the per capita cost is not great and that the works are surely worth far more than their cost.

If laws now hamper a well-managed community from installing such sanitary works, then special assessments or modification in the limit of bonded indebtedness should be made so that there will be no opportunity for the public health to suffer thru failure to expend wisely what is necessary for protective sanitary arrangements. An ounce of prevention is worth a pound of cure. In no field is this more true than in sanitation.

But the really dominating factor in the progress to be made in the sanitary field is the force of public opinion, and that in turn will be guided by the success attending the efforts along many channels to educate the public and have them appreciate what a sanitary, cleanly program for a municipality means to the health of every family. Then the financial burden under efficient management will not only be resisted, but it will be welcomed and insisted upon.

As regards that phase of nuisances which involve only the convenience and personal comfort of the community as distinguished from strictly sanitary aspects, it is reasonable to suppose that progress will continue, and become substantially proportional also to the advances made in the public demand thru modified laws and a more intelligent understanding by the community as a whole as to the significance of the factors at issue.

Injunction suits serve as a balance wheel and have distinct use in guarding against a continuance of undersized, poorly operated, and poorly located sanitary works.

SUMMARY.

The proper disposal of liquid and solid wastes forms an important branch of municipal housekeeping. Altho marked progress has been made in the past few years, there are numerous communities in which these branches of sanitation are causing a nuisance.

Some of these nuisances affect the public comfort and others are distinctly prejudicial to the public health. Unfortunately there are instances where sickness and death are produced among citizens who have cleanly surroundings in their own immediate households but who are incapable of completely protecting themselves from the disastrous results of inadequate municipal sanitation.

The cost of municipal works is always a factor, but as a general proposition an efficient program as to both installation and operation of modern sanitary works does not involve a cost out of proportion to the benefits received. A single epidemic causes the cost of efficient works to become insignificant.

Municipal officials in many instances have their hands tied, and this promises to continue to be the case until public opinion forces the adoption of adequate remedial measures. And public opinion in turn will advance only in proportion to the sanitary education of the general public.

SEWAGE DISPOSAL LEGISLATION AND SANITARY ECONOMICS.

By H. N. Roberts, Consulting Engineer, Longview, Tex.

Of recent years many states have, thru their legislatures, passed acts attempting to control the pollution of streams by regulating the disposal of city wastes. Some of these laws have been moderate, while on the other hand some of them have been very drastic in their provisions. This article has to deal particularly with the latter class of legislation.

With an open water supply secured from either lake, reservoir, or stream, the first flushing of the catchment area by a heavy rain will carry into the water supply the surface washings of farm lands, cow yards, and the various other sources of contamination which are found on uncontrolled catchment areas. This pollution of the surface supply will be at or near its maximum for from one day to several days, depending on the nature of the area and the distribution of the rainfall thereon.

On one stream which the writer had occasion to examine in eastern Texas, the duration of maximum conditions of stream pollution was about ten days for the majority of rains observed, with a five or six day approach to, and falling off from, maximum conditions. During the existence of maximum conditions of pollution from natural causes (the catchment area being sparsely settled with no sewers emptying into the stream) the river had a heavy black turbidity of from 6,000 to 8,000 parts per million (U. S. G. S. standard); a 20°-centigrade gelatine count of 50,000 bacteria per cubic centimeter; a 37°-centigrade agar count of 3,000 bacteria per cubic centimeter; with B. Coli group present in 40 per cent of the 0.2 c. c. samples examined, and present in 100 per cent of the 1 c. c. samples examined; dissolved oxygen about 5 parts per million.

It would be unreasonable for any law to require more than a stable and inoffensive condition of stream at these flood stages, or a condition of stream at other stages (after having diluted the entering sewage) no worse than the maximum condition of the stream

by natural causes at flood times. Shoaling of the sewage due to currents and winds or floating of the larger particles would not, of course, be called an inoffensive stream condition, and would have to be avoided.

Some of the more drastic state laws, however, require a great deal more than this. A certain stream in the eastern part of one of southwestern states has a minimum observed daily flow (during the past six years) of 24,000,000 gals. per 24 hr. with a maximum of about 300,000,000 gal. per 24 hr. A town near by, having an average daily sewage flow of 100,000 gal. per 24 hr., desired to consider the problem of sewage disposal; the state, when consulted in the matter, would not allow the effluent from an Imhoff tank to be discharged into the stream, but specified further treatment; a smaller and nearer stream could be used provided this further treatment were supplemented by sterilization "giving a low bacterial count"; this latter solution of the problem will be the more economical.

Another river in the central part of this same state has a turbidity of from 20,000 to 30,000 parts per million at flood stages with a correspondingly high bacteria count, is a large river and navigable. A large city on its banks recently held a bond election for the purpose of installing a disposal plant, the bond issue was promptly voted down, the next step being up to the state to prove its ability to enforce its stream pollution act when the voters refused to vote the bonds required. The reasonableness of the law will probably have to be proven in this case before the Supreme Court of the State.

Another city in this State, to which the writer was called in a professional capacity, is furnishing to its inhabitants as potable, a water showing the following analysis:

Bacteria per c. c. agar 24 hr. 37° C.....	465
Bacteria per c. c. gelatine 48 hr. 20° C.....	1810
Total iron, p. p. m.	11
Per cent times B. Coli in 10 c. c. samples.....	50

The International Joint Commission in their report of Jan. 14, 1914, has endeavored to define the meaning of the bacterial count and the presence of B. Coli, and this has been quoted as furnishing an approximate idea of a tentative standard. They classify a water

containing from 25 to 50 bacteria per c. c. agar at 37°C. 24 hr., and from 10 to 20 B. Coli per 100 c. c. as "considerable pollution," and further state that "a water belonging to this class requires unremitting care in its purification"; implying, of course, that this would be out of the question for use as a potable water without purification.

Judged by the above mentioned standard, how would the water shown above be classified? This same city is now agitating a sewage disposal plant.

Another near-by city, of the same size as the last mentioned, has had a sewage disposal plant in operation for a number of years, but is furnished thru a municipally owned plant, a water containing so high an iron content with much organic matter as to be highly offensive to taste and smell at times and to discolor white articles all the time.

While this discussion is being prepared a near-by town of about 5,000 inhabitants is fighting a typhoid epidemic, the cause of which has not as yet been located. An officer from the state health department has been with them for the past few days to assist them in locating the cause. This town has just installed a waterworks system and is getting its water from a small open artificial lake, using the raw water without any treatment or sterilization of any kind. The pond becomes shallow in late summer, the bottom of same being natural soil. This city is just in the midst of the construction of a sewerage system and disposal plant. Unfortunately an analysis of the water is not available for the purposes of this article.

These cases are a few of the more noticeable ones with which the writer has come in touch, and they serve to strengthen his conviction that, while sewage disposal legislation may serve certain ends, a dollar will go the farthest, save the most lives and doctors' bills, if invested first in personal cleanliness, clean-up campaigns, free serum and vaccine to the poor, and water purification and sterilization; thus the legislation on sewage disposal, while more important things are left without legislation, is surely premature, and not at all in accordance with the principle of sanitary economics which requires that the most good be done in bettering sanitary and hy-

gienic conditions for the largest number of people with the expenditure of the minimum amount of money.

It may be argued that these are infrequently occurring and isolated cases. If that be conceded, it must be conceded that for such cases the obligatory installation of sewage disposal plants will help the public welfare very little, if any; it may even actually work a hardship on the smaller towns where funds are scarce, and are badly needed in more important works of sanitation.

REPORT OF THE COMMITTEE ON WATER WORKS AND WATER SUPPLY.

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In attempting a review of water works practice now or at any other time, it obviously would be impossible to give anywhere near a comprehensive grasp of the situation without drawing much of the material from current reports, papers, etc. And while we wish no inference drawn that this report is in any sense a complete one, we wish here to acknowledge and give credit to that legion of intellectual giants in the sanitary world who have recorded most of the facts from which this report is largely gleaned. Specific articles will be mentioned later. The proceedings of the 1915 convention, not seeming to be available at the present time, some of this report may overlap with that of last year.

The first thought in a water system is the supply. And in recent years the question of its sanitary quality is receiving more and more consideration. Legislation has also been developed along this channel, both in preventing pollution, and also in throwing safeguards around the selection of a supply by having it passed on by the State Boards of Health before the local municipal unit can legally proceed with the construction or enlargement of a system. To this end, somewhat like the mountain systems of Europe, the three largest supplies in the country have been projected at enormous expense in securing mountain streams, on account of the purity of the same—that is, New York City, Los Angeles and the Hetch Hetchy project for San Francisco. Those places which by environment cannot avail themselves of such opportunities have met their problem in other ways, such as prevention of polluting material reaching the supply by purchasing the whole or parts of the watershed, securing legislation for controlling the watershed, extending intakes into deeper water, and finally purification in some form. The application of hypochlorite of lime, and later, that of liquid chlorine, has increased in the last few years to an almost universal

practice, being used in some places as an adjunct to filtration, and in others as the only purification needed. During the last year or more there has been a great advance in the use of, and the apparatus for applying chlorine, brought about perhaps by several causes. First, the uncertain content of available chlorine in the hypochlorite of lime as compared to chlorine, and its easier and more positive application by the devices now on the market; and further, the enormous percentage increase in the cost of hypo against the smaller percentage increase in liquid chlorine. Also, tastes and odors seem to be less likely to occur in the latter, but it is undeniably true that they will occur with either on some occasions with a very slight overdose.

There is practically no method commercially used of actual purification except by filtration, either by the slow sand or rapid filter, either finding its best application according to the conditions of the supply; all of the muddy river waters being best handled by the rapid filter, and the slow sand being used for the clearer waters. The increase in the use of filtered water has been clearly set forth in papers by George A. Johnson, one of his last notable contributions being entitled "The Typhoid Toll," and it is earnestly recommended that everyone interested in sanitation read the whole of it. Some of the vital points brought out in this paper are, that the United States loses each year in vital capital \$150,000,000, due to the economic loss of life from typhoid fever, which is absolutely preventable; and a considerable percentage of this can be accomplished by filtration of the public water supplies. That is, all water-borne typhoid is eliminated by filtration. And as filtered water puts out fires as well as unfiltered, it should be a great incentive to use the filtered variety for fire protection, when it is further stated that in the last thirty odd years the loss in vital capital thru typhoid fever alone was over three times the net property loss from fire in the United States.

A table and diagram showing some facts regarding filtration with respect to typhoid, discloses the fact that in 1900 less than two millions of people were using filtered water in the United States, and in 1913 this was increased to 16,500,000 people, and for this urban population the typhoid death rate decreased from 42 to

14 per hundred thousand. Other equally impressive statements are made, which I leave to the thoughtful reader.

The Department of Commerce, Bureau of Census, has just released a document for public use, relative to filtration, which is headed "Water-Supply Systems of American Cities. Decline in Typhoid Death Rate Follows Improvement of Water Supply."

Some of the pertinent subjects mentioned, I will quote as follows :

During this same period (1903 to 1914-15) there has been thruout the country a remarkable decrease in the death rate due to typhoid fever. Altho this decrease has taken place in both urban and rural localities, it is noteworthy that in most of the large cities which have recently built or improved and enlarged their purification plants the decline has been greater—in some cases very much greater—than the average decline elsewhere. For example, in Cleveland the typhoid death rate fell from 111 per 100,000 population in 1903 to 8.1 in 1914; in Philadelphia, from 72.3 to 7.6; in Pittsburg, from 132.7 to 15; in Cincinnati, from 42.2 to 6.2; in Chicago, from 32.5 to 6.6; in St. Louis, from 52.6 to 12; in Washington, D. C., from 48.5 to 11.9; in Minneapolis, from 41.1 to 12.5, and in New York City, from 17.1 to 6.3.

Cost of Water-Supply Plants.

The growing solicitude for the purity and adequacy of the water supply is further indicated by the very considerable increase which has taken place during recent years in the amount invested in municipal water-supply plants. The total capital invested in these plants in 1903-4, in the 105 cities of over 30,000, which owned, either wholly or in part, and operated their water systems, and for which data are available, was, in round numbers, \$513,000,000, representing a per capita investment of approximately \$29. In the fiscal year 1914-15 the number of such cities owning their plants had increased to 155, the total investment to \$1,071,000,000, and the per capita investment to approximately \$38. The increase in the per capita investment during the eleven years thus amounted to 31 per cent.

While it is, of course, quite true that an adequate supply of pure water can be provided for one city at a far less per capita cost than for another, by reason of differences in the construction problems involved or in the nature of the sources from which the water is obtained, the fact of prime significance brought out by the report is that an efficient system is now regarded by most cities as an economic necessity and hence is acquired, regardless of the cost.

In a paper by John W. Alvord, before the International Engineering Congress, on municipal water supply in the United States, the following statement in relation to filtration is made. And when an engineer of his attainments makes such a broad statement, it carries with it considerable weight. The statement is as follows:

Practically all river and large lake municipal water supplies, and many impounded supplies, must eventually be filtered to meet the rapidly spreading demand for uniformly safe and potable water. We may reasonably look forward to an extension of water filtration during the next decade fully as great as the growth from 1904.

After all has been done to secure a good supply, either in the original or from filtration, quality is further a watchword in operation. The larger works make numerous bacteriological tests to determine factors of manipulation; and the medium to small works are no longer satisfied with less than daily examinations.

At this point it might be well to state that methods of handling filters have developed into some practices which were not thought of a short time ago. Two instances only will be mentioned as coming under the observation of the Committee.

At Wilmington, North Carolina, in the matter of decolorization, the operator, basing his method on the theory of colloids and of electrification of the separate particles, has produced a clear water by neutralizing the positive charge by soda ash and alum together. It is quite possible that in the future such electrical discharge may be produced by physical, rather than by any chemical means.

The other fact mentioned is discussed in a paper by Mr. E. E. Lockridge, of Springfield, Mass., which was presented at the New England convention in September, which shows an economy of operation and other desirable results by some intermittent overdosing.

These are simply brought out to show that live operators are taking advantage of conditions in their own plants affecting economies, and showing better results in the production of pure water.

After all possible has been done to secure the continuing proper sanitary quality of a supply, the question of adequacy is examined. This is a reversal of original practice, because it used to be, Be sure of your quantity, first. But at the present time, that has to be thought out after the quality has been proven. And some operating

plants, at least, have found that when the supply was approaching its limit, or the distribution was insufficient for proper fire protection, the day for an increased supply, or the rebuilding of the system of distribution, pumps, etc., to an enlarged capacity, was indefinitely postponed by a consistent endeavor to prevent waste. This may be accomplished in many ways, and the earnest manager can readily find some system to meet his needs. This phase of waste has not received the attention it deserves.

Not longer ago than September, of this year, Mr. Frank A. Barbour made a committee report to the New England Water Works convention, giving some facts showing the inattention he received from water works superintendents relative to their leakage and waste. And while it may appear in the minutes of the report that there was no discussion on his paper, the thinking manager, we believe, would have welcomed a discussion, if it had been allowed at the time. The subject of waste has not received and is not receiving the attention it deserves. We are far behind Great Britain and the Continent in this respect.

Altho there have not always been the most cordial reciprocal relations between the water works and the underwriters' bureaus, there is now a better understanding, due to more definite terms and rules as to what constitutes proper fire protection. And it may yet take to the time when the lion and the lamb lie down together, that they will agree on all points; but they have done so well in the last year or two, that we hope this state of affairs may exist before the coming of the millennium.

In mentioning fire protection, that carries with it immediately, not only the question of adequacy of supply, but pressure in the mains. And in some of our larger cities, in the high-value districts with tall buildings, separate systems of high pressure lines are laid in which the quality of the water is entirely a secondary consideration, but which can be furnished either from tide waters or large streams in unfailing quantities at a pressure higher than that carried by any normal supply. This means, also, a development of high service pumping engines which are able to do this without any failure and at a reasonable cost. The development in pumping engines also has made it possible to secure a duty in foot-pounds per 1,000 pounds of steam of 175 to 180,000,000.

The ownership of water works continues to go over into the municipal column, and undoubtedly this practice will continue, so that it will not be many years before a privately owned plant will be quite an exception to the general rule.

Finance.

The finances of municipally owned plants are much better understood than they were a few years ago. And while there has been but little work done in the conventions relative to the financial policy, it is creeping in more and more, and at the last New England convention a forenoon was given over to the discussion of the accounts of the department—which is simply an index that shows the tendency of the times.

The Census Bureau has issued a pamphlet on uniform accounts for systems of water supply, which is applicable from the very smallest to the very largest plant. It follows more or less the same scheme promulgated by the New England Water Works quite a number of years ago, and also accepted by The American Water Works Association. This, perhaps, has all been brought about more or less by the activities of our Public Service Commissions, which have been established in different states, relative to the regulation of rates and to the taking of plants by municipalities. Certain rulings have been made which have been a great guide to courts and juries in establishing reasonable rates for the different classes of service. While in general, municipal plants do not come under the jurisdiction of all of the Public Service Commissions of the states, some of them do. Notably, in Wisconsin this is true, and it has resulted in some of the municipal plants of that state being ordered to collect from the municipalities they served a certain percentage of the income from the general tax for the hydrants furnished for fire protection in their borders. This has a tendency to establish what we believe water works managers should insist upon, that the municipality they serve should raise by general tax some amount of money for part of its income, so that the entire burden may not be placed upon the rate payer. This, we believe, would result in a more equitable rate for both the rate payer and the taxpayer; for the taxpayer is benefited by a good water department in reducing his cost of insurance. And at least, he ought to be willing

to contribute a part of this saving to the department which made it for him. For it is a well-known fact that as between a water works system built solely for domestic and commercial use, and one built for the same purposes and that of fire protection also, there is a great added cost, the percentage, of course, depending upon the size of the city, the smaller the city the larger the increased percentage for the fire protection cost. These facts, by the above noted action, are being recognized and adjusted in order that in the future more equitable rates may be obtained, and that an adequate income may also be obtained for the expenses and maintenance of the water works in our country.

SOME NOTES ON BREAKS IN CAST IRON PIPE LINES.

By R. DeL. French, Lecturer in Municipal Engineering, McGill University, Montreal, Que.

There is scarcely any community of size on this continent which has not, at some time or other, had failures in the mains of its water distribution system, which were, or seemed to be, inexplicable. Some cities have been most unfortunate in this respect, for example, Philadelphia, whose Hartwell Avenue line had no less than sixty-seven breaks in it between 1893 and 1915, and Louisville, where there have been forty-nine breaks in a 48-inch main since 1891. In 1913, Cincinnati suffered an almost complete water famine due to a serious break in its 60-inch supply main, which caused much damage and the loss of three lives. There have been two breaks in 30-inch distribution mains in Montreal within the past two or three years, both in streets of heavy traffic, with the result that the city has been mulcted for damages by near-by residents, whose cellars and dwellings were flooded thereby. Quebec built a new supply main of 40-inch and 44-inch pipe only recently, but has already suffered from breaks in it.

It is apparent that the prevention of such breaks is an important matter, and a study of the incidents leading to these disasters will help us to understand the reasons for them. Knowing these, the search for remedies may begin.

Sometimes a pipe line seems to be afflicted with an epidemic of failures, such as those at Philadelphia, Louisville and Quebec. These epidemics are generally confined to large pipes, usually supply mains. In such cases, it would seem natural to suspect that the characters of the pipe was at fault. Isolated breaks, like those in Montreal or Cincinnati, may, of course, be due to defective pipe, but they are more likely to be caused by defective workmanship in laying, or by local influences, such as settlement or excessive loading.

To the credit of the pipe founders it must be said that there is now seldom any fault to be found with the quality of the material

of which their pipe is made. In the case of the Hartwell Avenue main in Philadelphia, however, it was thought that the primary cause of the many breaks was the poor quality of the iron, the analysis of which, compared with that of a standard pipe iron, is given below :

	Hartwell Ave. main.	Standard pipe iron.
Silicon	1.850 %	1.500 %
Sulphur .....	.097 %	.070 %
Manganese .....	.361 %	.310 %
Phosphorus	1.330 %	.500 %
Combined carbon .....	.526 %	.350 %
Graphitic carbon	2.756 %	2.500 %
Iron	93.080 %	94.770 %
	100.000 %	100.000 %

Note that the phosphorus is about two and one-half times as high in the case of the Hartwell Avenue pipe as in the standard pipe iron. One-half per cent. of this element seems to be about all that it is safe to allow in irons from which strong castings have to be made. The more phosphorus there is, up to about five per cent., the better will the molten iron fill the finer parts of the mold, but the more brittle will the resulting castings be.

A common fault of manufacture in the days when pipe were cast on their sides was the failure to anchor the cores rigidly enough so that they would not float out of position, thus causing thin spots on one side of the pipe. Since all pipe are now cast vertically, this defect is not often noticed.

If a casting is removed from the mold too soon, and cooled too rapidly, internal stresses are set up which may greatly reduce its strength. In connection with some improvements to the water supply of St. John, N. B., some years ago, it became necessary to have a special tee cast. This special was needed in haste, and the local foundry rushed the work, and produced what appeared to be a first-class job. However, when put in place in the line, the tee broke almost as soon as the pressure was turned on. A second tee was then cast, and was allowed to cool slowly in the mold and protected from drafts, etc., for some time after being drawn, with the result that it proved perfectly satisfactory.

The numerous breaks in the Quebec line are thought to have been due to the fact that the pipe was cooled too rapidly. It is known that the foundry making the pipe, a Scotch one, was behind hand

in its deliveries, and that the city was constantly urging speed, so that this would seem to be a reasonable theory.

Unfortunately, there does not seem to be any method of easy application for determining with certainty whether or not castings have been properly cooled. Several have been suggested, but no one of them is known to be entirely satisfactory.

Between the foundry and the job there is an opportunity for pipe to become damaged in transportation. Care in packing for shipment, and inspection at the destination while unloading will prevent transportation cracks, or detect them if they occur.

Once the pipe is delivered alongside the trench, the responsibility for a first-class piece of work rests with the engineer. Of course, it is a prime requisite that the pipe shall be of proper thickness for the pressure and loads to which it will be subjected. There is not much room for choice on this point, as practically all pipe are now made to conform to one of the standard specifications, which provide proper thicknesses for different pressures. After this, it is a matter of care in laying. It is perhaps not necessary to describe the exact methods to be followed, nevertheless, it will do no harm to note a few of the precautions to be taken.

All pipe should be well bedded and have holes dug for the bells, so that they will be evenly supported thruout their entire length. There should be a space of a quarter-inch or so between the ends of the spigots and the bottoms of the bells, to allow for expansion. Failure to observe this precaution is thought to have been partly responsible for the very serious break in Cincinnati in 1913. The pipe should be securely anchored at changes of direction. The backfilling should be carefully and thoroly rammed around the pipe to a point well above its top, for a pipe that is well supported by the earth at its sides will carry a much greater external load than will one in which such support is lacking. The location of the trench itself should be so chosen that the pipe will not be subjected to heavy loads from traffic or from other sources. The Cincinnati pipe line was located in ground which had been subject to land slips, as shown by the broken and folded strata thru which the trench passed. It is possible that a fresh disturbance of the ground had something to do with this failure.

Water hammer is frequently blamed for pipe failures. This

action is present in some degree and at some time in practically all systems, and may be due to faulty design or to faulty operation. A certain minimum amount is probably inevitable. In small direct-pumping systems, the fluctuations in pressure are often very marked. Hydraulic elevators drawing from a small system will also produce similar fluctuations.

If water hammer alone were responsible for breakages to any great extent, one would expect to find such breaks in the small pipes near the source of the pressure fluctuations, and also that the breaks would be recurrent, unless the cause of the water hammer were removed in the meantime. As a matter of fact, failures in series have been most common in large supply mains and under circumstances which preclude the possibility of water hammer being responsible for them. Moreover, the accepted formulas for the thickness of cast iron pipes all make a liberal allowance for the effect of water hammer, so that, altho the final touch may be given by it to a pipe which is already cracked, it is not likely that it is solely responsible for many failures of well laid pipe of good quality.

To sum up, it is the writer's opinion that the answer to the question, "How shall breaks in cast iron pipe lines be prevented?" is to be found in inspection. Such inspection should cover

1. The manufacture of the pipe, including the control of the mixture of the irons by analysis, the molds, the usual hydraulic tests, and particularly the drawing of the pipe from the molds and the subsequent cooling. Just what rate of cooling is permissible is a matter which should be within the knowledge of the foundryman. The best man for a position such as required by this inspection would be one who had served his time at pipe founding. The analyses should, of course, be made by a competent chemist. Such inspection is now required by some of the larger cities.

2. The inspection of the loading of the pipe into cars or vessel, to be sure that it is as well packed for shipment as is practicable. On arrival at its destination, the pipe should be given a hammer test on unloading, and, if the work is of importance and the pipe is large, another inspection at the trench side would be quite in order.

3. Inspection of laying, which should be preferably in the hands of an engineer, or in those of a "practical" man under the immediate control of the engineer.

A complete system of inspection, as advocated above, will cost more than is now commonly thought allowable, but it appeals to the writer as being the only way in which it is possible to guard against inferior pipe and inferior workmanship. A city's water supply is one of its best assets, and interruptions to it, even tho they be unaccompanied by actual monetary damage or loss of life, expose the health of the citizens to grave dangers and their property to a greatly increased fire hazard, as well as contributing to an indirect financial loss thru the stoppage or curtailment of industry.

DISCUSSION.

THE PRESIDENT: There are one or two points I want to mention. In Hamilton we found pipe broken and in each case we found it was caused in unloading by rolling them against each other. In regard to an epidemic in Quebec of breaking, pneumatic calking was used there, I think. I was wondering whether in using 100 pounds of air pressure, some of the men had not calked it so hard as to break the pipe.

MR. FRENCH: In connection with the Quebec case, we had nothing to do with the line until after it was all laid, and then we were called in on behalf of the contractor, there being a dispute between the contractor and the city. All the information I had in regard to the Quebec line was what I could pick up myself. I saw none of the pipe laid, but did see some of the pipe that was broken. It may be, as Mr. Macallum says, that there was some damage done to it by the laying. I do not recall that any one that we interviewed mentioned that point to us.

THE SCIENTIFIC CLEANING OF SETTLING BASINS.

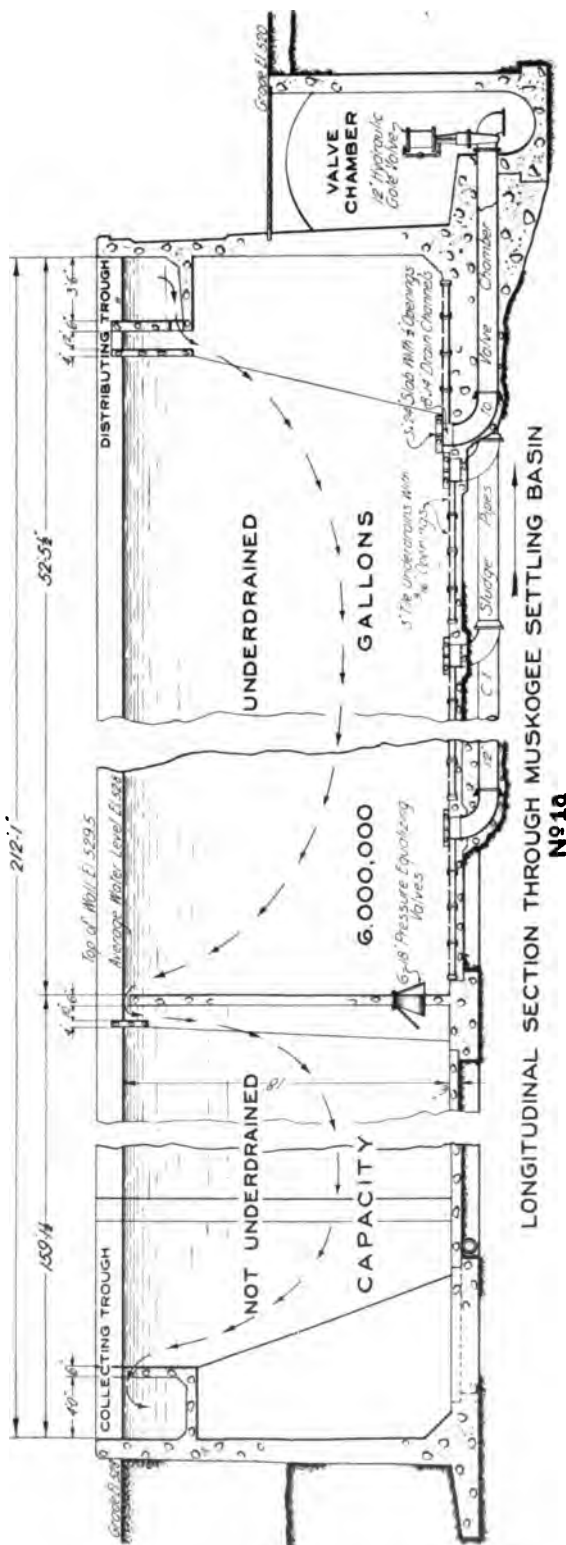
By Alexander Potter, Consulting Engineer, New York City.

In December, 1915, the writer listened with considerable interest to the reading of a paper describing the evolution and advance made in the cleaning of settling basins. In that paper the author outlined the development of the art from the primitive method of decanting the settled liquid from a settling basin and permitting the precipitated material to drain sufficiently to handle, to the modern process of erecting an electrically-driven pump on a float resting on the surface of the water of the settling basin and removing by hydraulic dredging the precipitated solid matter. The advantage of the method thus described is that the accumulated sludge is raised sufficiently high to permit its discharge upon low lands in the vicinity of the plant, thus performing the double function of keeping the sludge out of the stream and reclaiming restricted areas of land.

Concerning this method, which will be described in this paper, the writer claims no credit for originality, but does claim credit for its application upon large and workable scales.

A number of settling basins have been constructed by the writer in the last ten years in which the sludge deposits are removed at frequent intervals thru small perforations built in the bottom of the basin, and without interfering with the settling process, which is carried on continuously. The first plant of any size in this country in which this principle of a perforated bottom was used, was that at McKeesport, Pa., a plant designed to treat 10,000,000 gallons of water daily. To show the skepticism with which such a construction was viewed, the writer quotes from the published report of the engineer of the State Board of Health in passing upon the plans submitted for the McKeesport plant:

Probable trouble will be experienced, as is usually the case, with the sediment-removing or draining device, and at times it will be necessary to drain each quadrant to admit of complete removal or repairs. The attention of the city authorities is called to the ad-



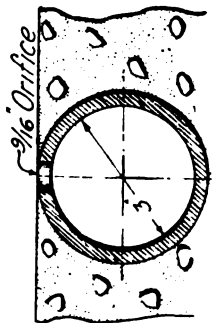
visability of affording facilities to obviate wasting the great bulk of softened water at the time of draining any settling tank compartment.

These predictions are not borne out by results, for at no time since the plant has been put in commission has any trouble whatever been experienced with the clogging of the perforations in the bottom of the settling tank. Quoting from the official report, dated December 31, 1911, of E. C. Trax, the operating chemist of the McKeesport filtration plant, "the settling basins have been efficient in removing most of the sediment and chemical precipitate from the water and have effected a satisfactory bacterial removal. It has not been found necessary to drain and clean any of the basins during the year, nor does there appear to be an excessive accumulation of eludge; it is evident that the blow-off system is working in a highly satisfactory manner." The writer has kept in touch with this plant since that time and has been advised by the chemist that no difficulty whatever has been experienced up to the present time with the sludge removing device.

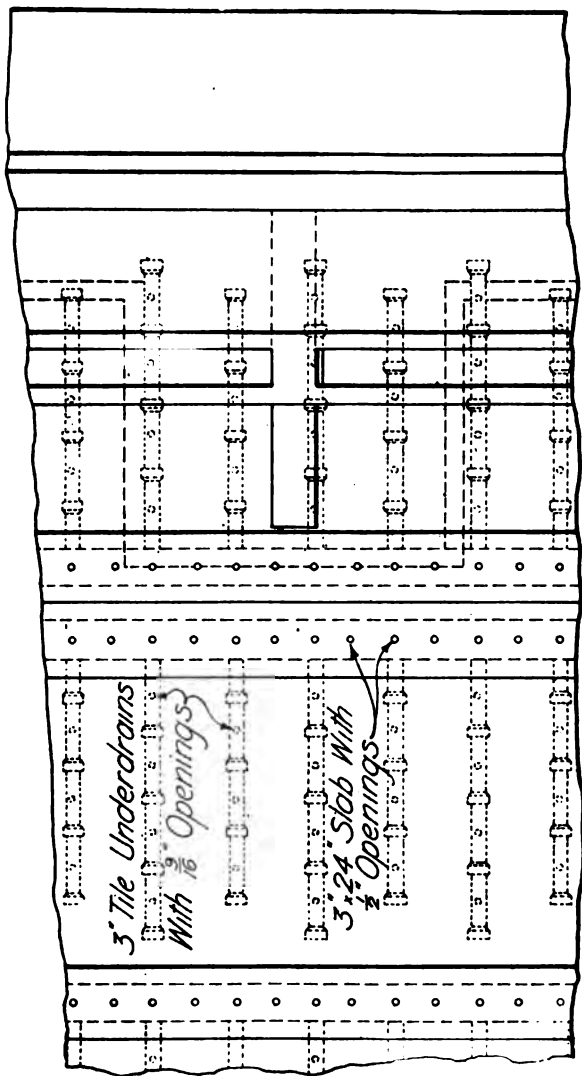
The conditions at McKeesport are at times especially trying on the sludge removal apparatus, for there are periods, of short duration, when the precipitation reaches almost ten per cent. by volume of the water treated, and in the treatment a million pounds of lime and a million and a half pounds of soda ash have been used annually. The cost of removing the precipitated material at the McKeesport plant has averaged about 35 cents per million gallons of water treated. The ratio of blow-off water to water treated ranges from 1.4 to 8.9 per cent. when the water is bad, and averaged 2.3 per cent. for the period that the plant has been in operation.

The largest settling basin built by the writer in which this method of sludge removal was used is the 6,000,000-gallon settling basin at Muskogee, Okla., completed in 1912 and described in the Proceedings of the American Water Works Association of that year.

In examining the performance of the McKeesport plant it was found that about seventy-five per cent. of the precipitation took place in the first quarter of the tank; consequently, in designing the Muskogee plant the perforated bottom extended over twenty-five per cent. of the tank, and at this point a curtain wall was con-



DETAIL OF UNDERDRAIN



PLAN

Nº1b

structed and the water was forced to pass over the top of it. Experience has justified the decision of the writer, for examinations made on two occasions in the three and a half years that the plant has been in operation showed the amount of deposit in the unperforated portion of the settling basin varied from a depth of three inches at the curtain wall to an inch or an inch and a half at the far end.

When the Muskogee work was undertaken the writer was again warned of the probable failure of the sludge removal system, notwithstanding the success attending its installation at McKeesport, the argument being raised at that time that, whereas the McKeesport precipitate was a flocculent precipitate, due to the high chemical content, the precipitate at Muskogee, being of a silty nature, the perforations would undoubtedly become clogged. To date no such condition has arisen.

As this method of sludge removal is still considered by many engineers as impractical, the three and a half years' experience at Muskogee with this method of sludge removal should prove interesting.

DESCRIPTION OF MUSKOGEE SETTLING BASIN.

The Muskogee settling basin is constructed of reinforced concrete. It is 212 feet square and 19.5 feet deep. When filled to a depth of 18 feet its capacity is 6,000,000 gallons. A reinforced concrete curtain wall, 6 inches thick, supported by buttresses at intervals of 12 feet, divides the basin into two compartments. The first and smaller of these compartments, 52.5 feet wide and 212 feet long (about one-quarter of the basin), has its bottom perforated and underdrained for sludge removal. To underdrain the larger compartment was not considered advisable, first, because of the expense and, second, based upon the experience in other plants where the writer adopted this method, it was not considered necessary because of the relatively small quantity of suspended matter which experience indicated would settle out in this compartment. Three and a half years' continuous operation shows it to average about 1.3 per cent. as opposed to 98.7 per cent. removed over the area with the perforated bottom.

Fig. 1 is a section of the Muskogee settling basin taken parallel



Fig. 2. June 18, 1913. Washing Basin No. 1. Quindaro.

to the direction of flow. The raw water, treated with sulphate of iron and hydrated lime at the average rate of one and two and one-half grains per gallon respectively, enters the settling basin at the left thru the distributing trough. From the distributing trough the water is admitted to the first compartment of the basin thru thirty-two 8-inch circular openings. A vertical concrete baffle wall, 4 inches thick, constructed directly in front of these openings, tends to arrest all eddy and vortex motion and at the same time deflects the incoming water downward.

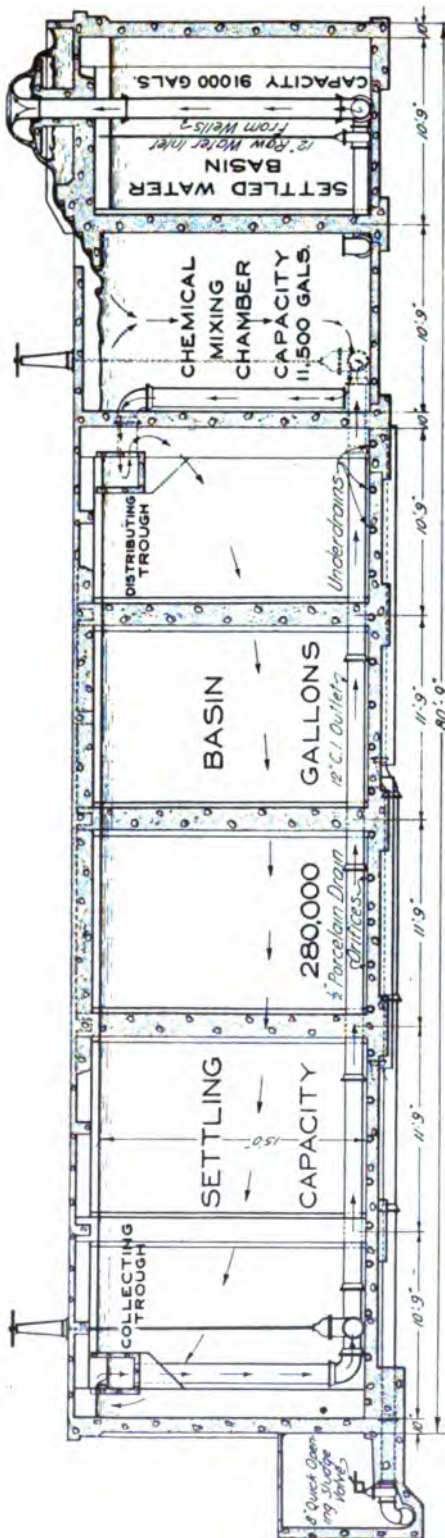
The partially settled water passes from the first to the second compartment over a submerged weir formed by the curtain wall. The crest of this submerged weir is about 6 inches below the average water level maintained in the tank. To assist in arresting vortex motion set up in the water as it passes over the submerged weir, a 4-inch stilling wall has been placed in front of it. The settled water is drawn off into the collecting channel over a series of weirs. The water level in the basin as operated varies between elevation 527.5 and 528.0.

To remove the sludge from the first compartment, 3-inch bell-and-spigot vitrified-stoneware drain-pipes have been laid in the concrete floor, which is 9 inches thick. These drain-pipes are arranged in parallel rows 27.5-inch centers in five distinct zones. These zones are laid out with the view of having the sludge deposited uniformly over the area of any one zone. Each zone consists of a main collecting channel 8 inches wide and 4 inches deep into which the 3-inch under-drains discharge. The 3-inch under-drains are made up in 2-foot lengths and each length is perforated with one circular hole $\frac{9}{16}$ of an inch in diameter. The cover plates of the main collecting channel are perforated with $\frac{1}{2}$ -inch circular holes spaced $13\frac{3}{4}$ inches centers. Twelve-inch cast iron pipes convey the sludge from the various zones to the sludge well. Tributary to each zone are 315 holes or perforations $\frac{9}{16}$ of an inch in diameter, and 180 perforations $\frac{1}{2}$ inch in diameter, giving a total area of 113.4 square inches—practically the same as the area of a 12-inch outlet pipe.

OPERATING RESULTS.

The plant treats an average of 3,000,000 gallons per day. The total solids in the raw water, which is taken from the Grand River,

AERATOR



MOORESTOWN DEFERRIZATION PLANT
SECTION THROUGH SETTLING BASIN
FIG. 3

ALEXANDER POTTER
ON THE CLEANING OF SETTLING BASINS

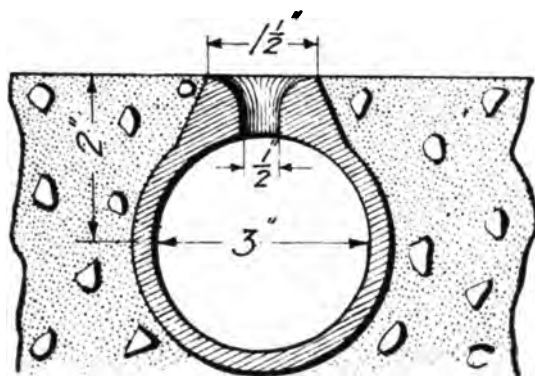
average 451 parts per million. This is increased by 64 parts per million by the hydrated lime and sulphate of iron applied to the water before it enters the settling basin. Of the total solids in the water after being treated with the chemicals, 44 parts per million settle out in the mixing chambers and distributing troughs, 307 parts per million in the first compartment, i. e., the first quarter of the settling basin, and only about 4 parts per million in the second compartment.

The collecting trough, as constructed, acts as a settling basin and tends to fill with sediment, thereby interfering to some extent with the uniform distribution of the coagulated water. Altho much of this sediment is washed into the basin by the increased velocity set up in the distributing trough when the sludge valves are opened, periodic hand-cleaning is essential to secure the best results. Hand-cleaning could be avoided by reducing the area of cross-section of the trough and shifting the circular openings from the side to the bottom.

The total solids in the settled water amount to 160 parts per million, practically all of which is in solution. The water after it leaves the settling basins is, with very few exceptions, uniformly clear and free from suspended matter. The Grand River water is comparatively free from microscopic particles of clay. Very rarely, however, due to abnormal hydraulic conditions, the Arkansas River water finds its way up into the Grand River, and then difficulties are experienced in coagulating and removing these microscopic particles of clay nearly always present in the water of the Arkansas River.

The average rate of removal in the second compartment, based upon the total amount of solid matter collected in the second compartment when the basin was emptied for cleaning after two and a half years of continuous operation, averaged about 4 parts per million, which represents $1\frac{1}{8}$ per cent. of the total solids removed by settling.

As the Muskogee plant treats an average of 3,000,000 gallons of water per day, the weight of the dried solid matter which accumulates daily in the first compartment amounts to 7,690 pounds. This solid matter is highly diluted with water and forms a very thin



**MOORESTOWN DEFERRIZATION PLANT
DETAIL OF UNDERDRAIN AND ORIFICE
FOR
SLUDGE REMOVAL SYSTEM**

FIG. 4

sludge which is neither sticky nor gelatinous but resembles a fluid of very low viscosity.

The daily accumulation of sludge, based upon a water content of 90 per cent., covers the first compartment to a depth of 1.25 inches in twenty-four hours. At this rate of deposition the first compartment would be half-full of sludge in 130 days, making due allowance for the compressibility of the sludge. In the three and a half years of continuous operation of this basin the settling basin has been out of commission but once for examination, at which time there were removed about 3 inches of sediment deposited in the larger compartment. The first, and underdrained, compartment was at that time found to be practically free from any considerable

quantities of sludge, and no clogged perforations or drains were detected.

The following table gives the most important facts relative to the operation of the sludge removal system at Muskogee-

TABLE I.
Data Relative to Sludge Removal.

Average total weight of dry solids removed daily by underdrains in the form of sludge, lbs.....	7,690
Average water content of sludge as discharged thru blow-off valve, per cent.....	98.7
Total quantity of sludge water discharged at one operation, gals.....	70,000
Ratio of blow-off water to total water treated, per cent.....	2.32
Effective hydrostatic head for sludge removal, feet.....	20.5
Average velocity thru underdrain perforations, feet per sec.....	20.4
Loss of hydrostatic head thru perforations, 26.3% of total head, feet..	5.4
Hydrostatic losses in underdrain system, 21% of total head, feet.....	4.2
Velocity head lost at discharge, 52.7% of total head, feet.....	10.8

COST OF SLUDGE REMOVAL.

The total cost of constructing the sludge removal system for the Muskogee settling basin over and above the cost of constructing a plain tank of similar shape and size, and including all piping, valves, sludge chamber, etc., was \$3,570. This is at the rate of 32.5 cents per square foot of bottom underdrained. The average annual cost of operating and maintaining the sludge removal system, including all fixed charges, amounts to \$523, and is made up as follows:

TABLE II.

Interest and depreciation, 8% on \$3,570.....	\$286
Value of the blow-off water lost, 25,500,000 gallons raised 70 feet at 6¢ per million (including fixed charges).....	102
4,260 lbs. ferrous sulphate lost with blow-off water at 1.25 cts. per lb....	53
9,370 lbs. hydrated lime lost with blow-off water at 0.005 cts. per lb....	47
Attendance and supplies	34
Total annual cost.....	\$523

Total quantity of water treated—1,970,000,000 gallons.

Cost of sludge removal per million gallons of treated water—\$0.49.

Weight of dry solid matter removed in one year—1,404 tons.

Cost per ton of dry solid matter removed—\$0.37.

The above costs of sludge removal compare most favorably with the cost of sludge removal as practiced on a large scale at St. Louis, Nashville, and Kansas City. The costs of removing sludge given in the following table are taken from the municipal records, which, unfortunately, are not complete in that they only give the cost of labor, making no charge whatever for water lost and used in flush-

ing out the basin. A fair allowance has been made in these costs for water wasted and used for flushing purposes, and as corrected, the data are sufficiently accurate for purposes of comparison.

TABLE III.
Cost of Removing Sludge from Settling Basins.
(Exclusive of fixed charges.)

City.	Year.	Water Treated (mil. gal.)	Sludge Removed (cu. yds.)	Cost per cu. yd. of Sludge Removed
**Muskegee, Okla.	1913—1916	3,210	21,903	0.0469
**McKeesport, Pa.	1908—1913	8,890	96,000	0.0325
Main basin	1907	28,048	114,256	0.048
St. Louis, Mo.:				
Main basin	1908	29,156	135,108	0.048
Main basin	1909	34,201	129,035	0.051
Main basin	1910	33,910	182,500	0.045
Blasels Point basin.....	1908		4,000	*0.132
Baden storage reservoir....	1908		700	*0.213
Nashville, Tenn.	1908		4,500	*0.359

**Settling basins have underdrainage systems.

*Labor costs only.

While the cost of sludge removal by the process herein described compares favorably with the cheapest costs by other methods and is far cheaper than many, is it possible to compare upon the basis of cost the advantage of such a system, which insures at all times the full capacity of the basin, with, for instance, the settling basin shown in Fig. 2.

Again, as the precipitated solids in the settling basin would pass down the river if not deposited in the settling basin, there can be no serious objection to the return of these solids to the river, provided the accumulation is not retained too long to become a nuisance. The draining of the accumulated sludge once a day or every few days, is much to be preferred to the discharging at one time of such an accumulation as shown in Fig. 2.

At St. Louis it appeared to have been the practice of lengthening the period during which a settling basin may be kept in service by opening the mud gate five or six inches daily for a period of about an hour, or until the effluent is comparatively clear. None of this flushing water has been charged up against the cost of sludge removal. It is estimated that during the year 1910 approximately 193,000,000 gallons of water were used for this purpose in 175 days. Including the cost of pumping and treating this flushing water with chemicals, the cost of sludge removal becomes 29.3 cents,

which is about the same as the cost of removing the sludge at Muskogee.

At Muskogee the percentage of sludge water to total water treated is 2.33 per cent., which, in the writer's opinion, can be considerably reduced by careful management. This ratio of sludge water to total water treated compares quite favorably with that of St. Louis, where in 1910, the only year for which accurate data are available, 523,000,000 gallons of water were chargeable against sludge removal. Of this amount, 300,000,000 gallons were lost in emptying the basin, 130,000,000 gallons were used for flushing purposes, and 193,000,000 gallons were wasted thru the sludge gate, thus giving a ratio of 1.54 per cent.

Unless the sludge collecting in the bottom of the basin is frequently removed, the capacity and, indirectly, the efficiency of the basin is impaired by the accumulation of sludge deposits. Fig. 2, taken from the Annual Report of the Board of Fire and Water Commissioners for Kansas City, Mo., for the year 1913, shows the extent to which such deposits may accumulate in the common type of settling basin and interfere with the operation of the plant.

Fig. 3 illustrates a settling tank with perforated bottom designed by the writer for the removal of iron from ground water and erected at Moorestown, N. J. The iron deposits collecting in the bottom of the settling compartment are here removed weekly and without any interruption of service thru an underdrain system similar to that at Muskogee. Essential to the successful operation of such a system of sludge removal is a high velocity thru the sludge openings in the floor of the basin, and the frequent removal of the sludge, especially when this has a tendency to pack or solidify. In any one zone, also, the velocity thru the orifices must be fairly uniform so as to secure a uniform removal of the sludge. When the available head for sludge removal is small, as is the case in a shallow tank, a sufficiently high velocity can be secured by reducing to a minimum the loss of head at entrance and exit. The loss of head at entrance can be reduced by a rounded orifice, such as shown in Fig. 4, which shows the rounded orifice used at the Moorestown plant, and the loss of hydrostatic head lost with the sludge water can be reduced by enlarging the sludge outlet.

The writer is indebted to E. C. Trax, chemist, McKeesport, and Dr. Martin, chemist, and E. F. Peterson, city engineer, Muskogee, for data furnished in connection with the operation of these two plants, respectively; and also to A. H. Beyer, his principal assistant, for his collaboration.

DISCUSSION.

MR. HOWARD: Has any of that been used for fertilizer?

MR. POTTER: There is now under consideration some method of recovery of the sludge and its reburning, and it is expected to have not only sufficient lime recovery for all plant purposes, but some to dispose of.

THE WATER WORKS OF NEWARK, NEW JERSEY.

By Morris R. Sherrerd, Chief Engineer.

(Stenographic report of talk illustrated with stereopticon views.)

Newark had the pleasure of taking most of you to a portion of its water plant today. The Cedar Grove reservoir which you saw is really the receiving reservoir for the city's supply. The impounding reservoirs are about 21 miles—at least the intake of the water into the pipe from the impounding territory is about 21 miles—farther north than where we were today, and this is a map which shows the northern part of the State. The diagonal line near the top of the slide is the northern boundary line of the State, and in the lower right-hand corner is the city of Newark. The water is drawn from these three reservoirs shown on the slide thru the natural stream and gathered in an intake and taken in two 48-inch steel pipe lines and carried down into the northern end of the city. About five miles from the lower end is a branch 60-inch pipe line, which carries the water to the Cedar Grove reservoir, which has an elevation of 405 feet. From this reservoir we get direct pressure, so that at this hotel we have gravity pressure of about 150 pounds on our high-pressure hydrants.

This water supply is in a measure unique, in that the city has attempted to do perhaps more than any other city of its size has done in exercising the old adage of "an ounce of prevention is worth a pound of cure." The drainage area tributary to the city's plant is 63 square miles. The plant was built in 1892. It was a general contract for a supply of 50,000,000 gallons of water to the city daily, the construction of sufficient storage reservoirs and the pipe lines necessary to give that yield, at a cost of \$6,000,000. The original contract provided for land around the reservoirs, and that the company must provide at least 60 feet margin of area.

In 1896 the city first began the acquisition of property, buying what was then the town of Charlottesburg, in the lower portion of the water shed. Since then there has been adopted by the Board of Water Commissioners a consistent policy of continual acqui-



Forest Nursery of Newark Water Department at Newfoundland, N. J., showing 16,000 Scotch pine trees planted in the spring of 1916, and black walnut trees from seeds planted in the fall of 1915.

tions of land, until now the city owns, out of the 63 square miles, about 46 square miles of land. It has bought farms and it has removed the buildings and used the material for the construction of what we call our model village below the intake, where we house our employes.

My talk tonight will be more to show you some of the views, which indicate the result of the work in the water shed.

We have also inaugurated a scheme of reforestation on this property acquired by the city. The method of procedure has been to take such properties as are offered at what the board considers a reasonable figure. The board has been perhaps the best purchaser of properties, but it has bided its time to get certain properties until it thought the price was right. There has only recently been a contract entered into by the city which will cause the removal of what was our greatest menace, namely, the Standard Oil pipe lines, that come from the oil fields down to Bayonne across this water

shed. The city recently entered into a contract by which, at a cost of about \$45,000 on the part of the city, the company has agreed to remove these pipe lines and their oil stations, with their attendants, entirely from the water shed.

Here is shown a little clearer the relative proportions of the area of the city and the area of the water shed. The darker spots on the upper portion of the diagram are the impounding reservoirs. The water from the upper reservoir flows down into and thru the Oak Ridge reservoir and joins the stream which is the outlet of the Clinton reservoir, the most easterly one, at a point about three miles below the Oak Ridge reservoir. Then the water is carried down thru this main stream. There is one advantage of this arrangement in having the different reservoirs rather than one large impounding reservoir.

We now take samples of water in those reservoirs at least twice a week, and our principal troubles in this plant have been those of taste rather than any danger from pathogenic infection from germs in the water. When we have a growth in the Clinton reservoir which is likely to give taste to the water, we switch over to another reservoir, and vice versa, and we can take the water from the other reservoirs, and also have a chance to use separately the water from the Cedar Grove reservoir, which you saw today, which holds about two weeks' supply for the city. Our operation of the Newark water plant, from the point of view of giving us a high quality of water, is to use the Cedar Grove reservoir as a settling and clarification basin, and the city has adopted the policy that instead of waiting until the time shall come when the growth of population in this water shed might make it necessary to resort to filtration, it has, by the methods adopted, practically depopulated large tracts or portions of the water shed so that there are now no villages of any size in any of the 63 square miles.

While speaking in general terms of this water supply, perhaps I should give you some figures which show what has been possible in the way of reduction of cost of the water supply to the city. This new water supply was put in service in 1892, the contract price being \$6,000,000, of which \$4,000,000 was paid at that time and \$2,000,000 held in escrow until 1900, the company to operate the plant for eight years in order that the city might test its capacity,



Village for employes of the Newark Water Department under construction below the intake of the water distribution system.

so that the additional payment was not made until 1900. Taking the amount of water used by the city in 1892 and figuring the interest charges and operation of just the gravity plant, the delivering of the water into the reservoirs in the city at that time cost about \$50 per million gallons of water delivered. In 1900 the increased consumption from this plant, which has a capacity of 50,000,000 gallons per day, had reduced the cost of water to about \$26 per million gallons delivered into the city reservoirs. In 1900 the plant was taken over in its entirety by the city, and the additional \$2,000,000 of bonds was then outstanding, and the cost, on the same consumption, after this additional bond issue, went up to about \$38. In 1905 the Cedar Grove reservoir, costing about \$2,000,000 with its tunnel and pipe line connections to the city, was added to the plant, which again increased the interest and sinking fund charges, and similarly the operation, so that the cost in 1905 of water delivered to the city was about \$40 per million gallons. To-day, with a larger consumption, using about 46,000,000 gallons per day, the cost of delivering to the city reservoirs is about \$30. In 1922 the interest and sinking fund will be paid off, and the actual cost of operation of the city supply, namely, 50,000,000 gallons,



Watch Tower for forest fires on the reservation of the watershed of Newark Water Supply.

which will practically be a perpetual supply of that quantity, will be under \$5 per million gallons delivered to the city reservoir under pressure, so that it may be used without the necessity of pumping. Of course, it will cost the city on an average more than \$5 for its water, because it will be necessary at that time to get an additional water supply, for which plans are now in preparation.

(A number of slides were then thrown on the screen, showing various views connected with the plant, each followed by a short description by Mr. Sherrerd.)

DISCUSSION.

A MEMBER: How high is the upper reservoir you referred to above Newark?

MR. SHERRERD: The highest one is 1,086 feet. Clinton reservoir is 992 feet, and the Oak Ridge is 836 feet, and the intake is 585 feet.

REPORT OF COMMITTEE ON MUNICIPAL LEGISLATION AND FINANCE.

Fred J. Cellarius, Chairman, Consulting Engineer, Dayton, O.

Your Committee on Municipal Legislation and Finance has not been able to learn of any radical or novel legislation affecting municipalities having been enacted during the past year.

It can be affirmed, however, that the general tendency of municipal legislation continues to be in the direction of an increased measure of home rule for cities. This does not signify a disposition to enlarge the powers of municipal governments, but rather to give the voters of a community authority to determine by ballot what the wants and needs of a city are, and to place upon them the responsibility for their decision.

Finance is taking a more important position in municipal affairs than formerly on account of the rapid growth and concentration of population in cities and because their material and social progress depends upon it. Old methods are being discarded and new and better ones installed.

There appears to have been steady improvement by the municipalities themselves in their accounting methods, for which there was evidently great need.

One notable effect of increased popular interest in local governmental affairs has been the construction of financial budgets more scientifically than heretofore and hence the elimination of much guesswork in the making of appropriations.

Many municipalities are employing experts to teach their public servants the subject of scientific budget making. Here we find that there is a great need for more schools for public service.

As an illustration of what one municipality is doing in the way of budget making, it may be stated that Dayton, O., makes up its annual budget (based upon an estimate of the income for the year) upon a yearly basis rather than for a six months period, as has been

the custom. The budget is a segregated one rather than a lump sum budget, the items for proposed expenditures being very minutely set down.

The government of Dayton will not spend more money than it receives in revenue. Should the revenue estimated at the beginning of the year be not realized by at least August or September, the appropriations for the remainder of the year are reduced in proper proportion so as to enable the government to live within its means.

By having all the departments under one head, co-operation is secured, with the result that the departments have been able to carry on the work necessary with reduced funds.

Most cities, we believe, do not know what bills they owe until the bills are presented. The city government of Dayton has improved upon this by a system of accounting by which all funds are encumbered at the time the order is placed or the debt contracted. Should the goods not be delivered for some time, the appropriation remains encumbered just the same. If the goods are delivered, but not paid for, the liability is easily seen, so that at the close of the year, the city can show upon its balance-sheet its liabilities, together with the assets, about as clearly as can be done by a well-regulated manufacturing or mercantile establishment.

Government by commissions has within the past decade been adopted by very many municipalities. In some cities this form of government seems to have given general satisfaction; in others there is a wide diversity of opinion as to the merits or demerits of the governmental innovation.

The success or failure of any form of government depends largely upon the character of the men selected to administer it, and there was no reason to expect that this particular form of government would be an exception to the rule. It is safe to assert that the people of many communities regard the commission system as still on trial. They are accordingly awaiting the results of experience in the commission-governed cities before taking steps themselves to discard the old form of government for the new.

The city of Dayton, as most of you are doubtless aware, has for the past three years had what is known as the commission-manager

form of government. Very frequently the question is asked: "How do the people of Dayton like the city manager form of government?" It is a subject on which citizens of Dayton entertain widely different opinions, but there is reason for believing that a very large majority regard the new form of government as a decided improvement on the old.

No government can be a brilliant success unless it is backed up by a strong public sentiment.

To secure this support in the first instance is not so difficult as to retain it subsequently. Unfortunately, the people of all communities are spasmodic in the performance of public duties. When aroused on the subject of municipal reform, they become enthusiastic and energetic in their efforts to promote the public welfare, but after a time they lose interest in these matters and lapse into neglectfulness. Then comes a reversion to loose procedure that no form of government can avert. In brief, the success or failure of any form of government depends upon the citizenship of the community.

It cannot be too strongly impressed upon the popular mind that eternal vigilance is alike the price of liberty and good government.

CITY MANAGEMENT.

By C. A. Bingham, Norwood, Mass.

No movement for betterment of municipal government has received the amount of attention that the commission-manager form has during the past nine years. From its inception in 1907, at Staunton, Va., by accident, the growth has been phenomenal; at the present time one hundred municipalities, with a population totalling nearly 4,000,000, are using that form. So much has been written upon the subject that it is difficult to throw additional light, but for the benefit of discussion the following paper is presented.

The primary object is to eliminate the "spoils" system and personal gratuity phase so long suffered by American citizens. The framework is identical with that of manufacturing or general business organizations; namely, a board of commissioners similar to a board of directors, they elected by the citizens or stockholders; and the board in turn appointing a general manager, who appoints and has charge of the superintendents of various departments. Each unit is responsible to a higher authority. The superintendents may be removed by the manager, he by the board, and they by the people thru the recall. In twentieth-century parlance, it is a case of "make good or make an exit." Can anyone except a hide-bound politician object to the layout?

One grave error in a few charters is that the manager is subject to recall by the people at large, a very poor arrangement, because it is well nigh impossible to fearlessly perform public duties without incurring the dislike of those upon whom the shoe pinches. It is impossible to be all things to all men.

For the moment compare this clean-cut business organization with the old councilmanic form. The city cut into many wards, and occasionally the lines changed as the complexion of the voters migrates. In each ward a man is elected, many times upon pre-election promise to the ward heelers. This representative body divides into committees, each taking over the administration of an operating

branch of the government; then the log-rolling begins as to who shall have the berths, seldom resulting in the head of a department living thru a change of political faith—often, in fact, he is beheaded before he becomes well acquainted with his work. Now if you will bear with me a minute, we will follow it further. After it has been settled as to who is to have the appointing of each office, and friends have been selected, the new machinery moves. More street lights are desired in one section of the city and in order to get them, the representative from that ward votes with the gentleman from the sixth for his extra policeman, and so on. Surprisingly often the chairman of some committee owns a store and equally surprising is the fact that all city employes purchase their requirements there, regardless of prices, often carried so far that the pay checks are delivered by the treasurer to the lucky councilman. Of course, some people call the commission-manager form “tommyrot!”

Now we pass up a step and reach the straight commission plan, adopted by many cities upon the crisis of a flood, fire or other catastrophe, which found the old line government sadly lacking at the crucial moment. In this plan, there are elected at large five men, each of whom assumes complete control of a division of the government. While this system has brought many cities up out of the former political quagmire, yet it has three weak points.

First, often the same body appropriates the money that spends it. Second, the danger of the influential commissioner securing the lion's share of the budget for his pet department. Third, and most important, while a commissioner may be an excellent physician or a skilled barber, yet he is not a road builder nor a sanitary engineer, and he will not be able to secure an engineer with true professional ethics, who will countenance his interference. On the other hand, if he secures the reverse kind of an engineer, woe be to efficient public works.

Having passed thru these various experiences and probably numerous others, the wide-awake electorate is endeavoring to secure the addition of an official who will act between the board and its departments. In short, one who will run the government on their policies, but thru his execution. Unfortunately, many people have the wrong conception of his position and his duties; he is not an

autocrat, but is a "controlled agent" of the governing board. He does not control the treasurer, auditor or attorney (except, unfortunately, under a few of the very early charters). These men all check his financial operations. He cannot spend money for any cause whatsoever unless an appropriation has been passed for it in the annual budget by the Finance Commission, or by the voters, as the case may be. As in everything else, the plan will not work itself. Capable business men must be kept on the controlling board, men who are not swerved by private interests, but who will take interest in outlining policies for the advancement of their community, and yet who will not lag into either of the extremes of neglecting affairs entirely, or of interfering with petty details.

Then again, care must be used in the selection of the manager. Primarily, he should be an engineer with municipal experience. Again, the smaller the city the more difficult task he has, for he will be limited in the salaries he can pay his superintendents, thus meaning that he himself must do a larger amount of detail work in each department than the manager of a city many times larger, where he may be an inside executive entirely, trusting the details to high-priced directors. Unfortunately, some cities have selected as their man, the lowest bidder!

Before launching this plan, many preliminaries are necessary, which if inaugurated simultaneously would be such an upheaval that failure would surely result.

1. *Accounting and Budgets.* No business of whatever nature can long endure prosperity unless it has a thoro and yet simple system of accounting and cost-recording, and similarly it must work on a well-defined budget which will insure against the possibility of an over-draft or deficit in any appropriation. This budget and the resulting accountancy must be so devised that it will not only be comparable year by year, but will give details by which efficiency of operation and final accomplishments may be secured.

2. *Valuations and Tax Rate.* The assessors should be appointed on fitness by the governing board and not thrown upon the political seas. A re-valuation brought the tax rate of Norwood down from \$25.60 per thousand to \$12.80; the result is that a \$4,000 home formerly assessed at \$3,000 and paying \$76.80 taxes per year is now

assessed at the full value of \$4,000, and yet the assessment is only \$51.20. On the other hand, a man might have remonstrated at a valuation of \$75,000 and now be assessed in the millions. In short, it puts the burden where it belongs.

3. *Municipal Ownership.* This same community operates an electrical plant that not only receives no appropriation from public funds but donates \$15,000 free street lighting per year and builds its white ways and underground conduits out of profits. No wonder when a councilman in a certain Pennsylvania city reported that the city could save hundreds of thousands a year by operating a municipal plant, that a brother member shouted, "Aw, ferget it." The water, sewer and cemeteries are also municipally owned, but, of course, with less profit, altho often the earnings of one department are appropriated for some other branch of the government.

The last step is community spirit. Our community centers and allied activities are the finest levellers of citizenship possible. And in its forums have been sown the seed of good citizenship which recognizes neither politics nor religion. Can you gentlemen imagine a community where the contributing of 5 per cent. of your salary for the political pot is as unknown as the slide rule is to a coal miner?

Results—The speaker always shakes a doubting head as to the advisability when he reads a list of the wonderful accomplishments achieved in the first year or two in any community under the manager plan—for often you even fail to find them on the list the following year. But I do know for a fact that even in a municipality under 15,000 population you can work wonders by combining departments, eliminating unnecessary and superannuated fixtures, concentrating authority and converging the operating lines to one head. Costs of construction have been lowered as much as 55 per cent. and output increased 300 per cent. by simply common-sense changes, no efficiency buncombe. Without doubt the commission-manager form is the simplest way of eliminating politics and cliques in fire, police and other departments. As to purchases, any city, no matter how small, can save many times the expense of running a purchasing department, and enough on cash discounts alone to offset considerable of the clerical force.

THE ENGINEER AND THE PUBLIC.

A DISCUSSION OF THE WORK OF BUREAUS OF MUNICIPAL RESEARCH
AND STATE LEAGUES OF MUNICIPALITIES.

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A discussion of the relation of the municipal research movement to the municipal engineer must not be conducted in terms of "they," but in terms of "we." It is really not so much a question of the relation of the movement to the engineer as of the engineer to the movement. Municipal research is not a third-party movement. It is not "somebody else's" work, to which we are onlookers. It is our work. The movement might almost be said to be not even one for the engineer to "co-operate with," let alone be indifferent or hostile to: because co-operation implies a place outside the movement, whereas the engineer if he is doing his full duty in the public service, will be in the movement from the inside.

The engineer is no exception. The same truth exists with regard to the members of every other profession in municipal service. It is a safe statement that whatever be our task or title, if we are at all connected with municipal activity the municipal research movement offers each of us an opportunity to do constructive work that nobody else can do. But there are special opportunities open to the engineer, and there are ways in which he is specially qualified to get results from municipal research. These reasons, in addition to the special interest of this Society, have caused the limiting of the present discussion to a single important side of municipal research and its relationships.

To begin with, it might be a good thing if we had some sort of a Committee on Standard Specifications for Bureaus of Municipal Research, for in the course of the movement's development a number of paper organizations, of good intention but slight stamina, have assumed the title of municipal research bureau with-

out deserving it. This has been especially true among our colleges, as is evident from the data collected by a committee of the National Municipal League which has been investigating this subject and is about ready to report. Moreover, the active bureaus of municipal research are not all of one kind nor engaged in the same character of work. Some are supported by private subscription for intensive work in a single city. Some are maintained by privately endowed colleges or universities, and their activities are carried on principally in the city in which the supporting institution is located. Some are departments of our State universities, carrying on their work upon a state-wide basis. Still other bureaus exist as parts of a city administration, for the study of the efficiency of operation of the other units of that organization.

The movement started in New York City ten years ago. Taxes were mounting rapidly, and some of the heavy taxpayers were brought to the belief that municipal government could be lowered in cost if its principles were studied and its practice shaped to conform scientifically to them. The idea was not entirely a new one. Civic organizations of one sort or another had existed for years and had studied city administration in its various branches thru investigations carried on by committees of their members, sometimes with some clerical assistance. The new development was not the undertaking of new work, but the undertaking of the old work systematically and in a new way: namely, by the provision by citizens of funds for the employment of a *non-partisan staff of experts* to find out "what the government was doing, how it was organized, what methods were being used, what results were being obtained, and how the government might be made a more effective instrument for public service."

The success of the new movement encouraged interested observers in other cities. The New York Bureau was invited to undertake certain specific research work outside of New York, and from time to time has made surveys or conducted some kind of research activity in Philadelphia, Boston, Buffalo, Hoboken, Montclair, Pittsburg, Rochester, St. Louis, Yonkers, New Brunswick, New Orleans, and probably numbers of other cities. Sometimes partly as a result of this work, sometimes independently,

the citizens of other cities have taken up the idea, and beginning in Philadelphia, bureaus of municipal research have been founded by private funding or endowment in every quarter of the country. A recent list includes Akron, Baltimore, Buffalo, Chicago, Cincinnati, Columbus, Dayton, Denver, Detroit, Jersey City, Minneapolis, Milwaukee, Philadelphia, Rochester, Springfield and Toronto among the cities in which local research bureaus are operating. Doubtless there are other cities; and beside the cities at least two counties have regularly organized privately supported research agencies (Westchester county, N. Y., and Essex county, N. J.)

In much the same way, the "official" bureaus of research have been founded, those that, under one name or another, are organic parts of city governments. They exist in Chicago, Boston, Pittsburgh, New York, Los Angeles, Milwaukee, and perhaps some other cities. Sometimes they are attached to a municipal civil service commission. Sometimes they have been provided by "making over" an old department whose original purpose and usefulness has been outgrown. A striking generality applying to research bureaus of this type is the extent to which their existence represents foresight among officials. As contrasted with the privately supported bureaus, which exist largely because of the initiative of private citizens, these bureaus represent in large part the initiative of municipal officeholders, who have realized and tried to fill the need of their cities for some agency of inquiry into the unknowns and uncertainties of city government. It is worthy of remark that men of vision like these are of a color quite different from that which, for instance, certain of our public-service-corporation propagandists take delight in painting city officials.

The entrance of colleges and universities into municipal research results from two recent and very promising developments in the collegiate world. The first is the increasing importance attached to instruction in government and especially municipal government and administration. The mind of teacher and student has been turned from concentration upon the abstractions of political science to emphasis of the actual organization and operation of the units of government—the reason for their existence and the degree to which they fulfill their purpose. The

value of the interest thus aroused and the benefit from the knowledge thus gained can be compared only with the advancement that has come from the entrance of the classes and laboratories of scientific schools into the study of highway construction, water supply and sewage disposal.

Now, the engineering schools would not amount to much if all their instruction were drawn from books ten years old. They must keep abreast of current practice, as accounted for by the latest text-books and the current technical periodicals. They must supplement this with inspection trips and first-hand observation of local engineering phenomena, and with original investigation in their experimental laboratories. Similarly, the paraphernalia for teaching government no longer consists solely of a series of translations and a dusty set of the *Congressional Record*. The modern student of municipal administration must have access to the last item printed about his subject. Thru city reports, reference books and municipal periodicals he must keep in touch with municipal progress right up to yesterday and the day before. This makes it necessary for the college or university to have a municipal reference library. But that alone is not enough. The tendency is toward the study not of books about the city but of the city itself. The way must be opened for the student to observe for himself the phenomena of operation of city governments, and the advanced student must be enabled to carry on research that may add new items to our stock of knowledge about municipal administration. This need has led to the establishment of collegiate bureaus of municipal research. Harvard's Bureau of Research in Municipal Government is an example of this type of research agency.

The second development is in extension work. So much has been said and written about university extension that little need be said here. In its simplest terms, the movement is the application of a university's surplus resources to the work of the state at large. The information brought together on the shelves of a municipal reference library for the use of students is of even greater value to city officials and employees: for, while in the hands of students the information shapes the attitude and conduct of those who will deal with municipal problems in future years,

in the hands of present officials it has the opportunity to guide those who are leading our cities now. It would indeed be a waste of resources if this information were not put into usable form and made available to cities. So in many instances (for example, at the University of Wisconsin), the *municipal reference bureau* is holding a prominent place in extension activity. In some cases, indeed, the municipal reference bureau has been developed primarily as an extension activity, giving only a lesser part of its time to work in connection with instruction. In many instances, also, the purely reference work is supplemented by research in varying amount and with varying emphasis. A good example of such a research bureau, and the one most familiar to the writer, is the Bureau of Municipal Research and Reference of the University of Texas.

Is there a common spirit to be found in all this group? The elements seem diverse enough. We began with the bureau of municipal research as a private undertaking, an "agency of citizen inquiry," doing for the citizen things which the citizen lacks time and opportunity to do for himself, and making its reports and suggestions for his action. The municipal department of research is not an agency of citizen inquiry at all, but an official board of inquiry into departmental efficiency. The academic bureau of municipal research exists for what we may term informational study of governmental principles and methods. Meanwhile the first type of bureau, the private undertaking, has in some cases so changed its conception of its own functions that it no longer makes public all its investigations, but acts as judge of its own recommendations and settles the points of difference with the city administration without especially taking the citizen into its confidence. Yet, tho the elements are diverse, and tho they are shifting in the way characteristic of things that are young and have futures, there is a single spirit and purpose that appears in the activity of each of these various agencies. Municipal research is the systematic securing of knowledge about municipal affairs, on the principle that the more we know about cities the better we can make their administration. Every agency of municipal research is working toward this end. Methods differ. So do the particular lines of work that each agency finds itself able

to follow to best advantage. But there is a common goal: the determining of the unbiased truth at the root of each matter of inquiry, so that the truth may form the basis for efficient and virile administration. Furthermore, this common goal, together with the fact that the work is carried on systematically by a trained staff, is about all that all the various agencies of municipal research do have in common. We may therefore take these essentials as the outstanding characteristics of municipal research. Incidentally, it is on account of these essentials that the engineer is so well fitted to perform valuable service in municipal research. But let us note in order the different ways in which the movement comes close home to the engineer.

In the first place, the first piece of work undertaken by an organized agency of municipal research was an engineering investigation. When Mr. R. Fulton Cutting, (the man who first supported the Bureau of Municipal Research in New York, and therefore in a substantial way was the father of the municipal research movement), had his first staff ready for action in 1906, the intention was to begin a study of the government of New York City from public records of the various city departments. Access to these public records, however, tho a common law right of every citizen, especially confirmed by the city charter, was denied the young Bureau's investigators. Rather than sit idle and spend money in obtaining access to the books by judicial process, the Bureau decided to begin on some out-of-doors subject that could be studied to considerable extent without access to official records. The subject that lay closest at hand was the administration of the streets of Manhattan: and the memorable investigation that was begun led thru a series of official hearings finally to the removal of Boro President Ahearn on proven charge of incompetence.

This was just the first instance. It does not by any means stand alone. Aside from purely financial and administrative problems, it is doubtful if there is any more profitable area for municipal research than the field of work of the engineer. Naturally a movement instituted by taxpayers to save their tax money, or at least secure its efficient spending, finds its best opportunity in matters of finance. In the finance department all a city's money-

handling transactions are centered. Where the most money is handled, there is the biggest single chance to effect savings. And if the affairs of finance—sources of revenue, taxation and assessment, budget and accounting—thus promise the maximum return from a given investment of time and energy in research, administration is scarcely less important. Government has “just grown up” far more often than it has been planned ahead, and its unplanned organization is often not only rambling and cumbersome but actually an impedance to efficient work. Inefficient administration, chargeable to defective organization or to faulty administrative method or personnel, can and does appear in surprisingly near every city department. Matters of organization and administration have therefore a valid claim to second rank as a profitable research field. Beyond these, it is probably safe to say that no department of municipal activity offers so rich promise for municipal research as municipal engineering and public works. This may be because its affairs are visible and tangible and easily studied. It may be because they usually involve greater lump expenditures than any other branch of city work. It may also be because successful operation of some public works enterprises (municipally owned electric plants, for example) is fraught with danger to some private profits. Whatever the cause, the facts speak.

The Milwaukee Bureau of Municipal Research, for instance, recently devoted practically a whole year to an intensive study of the public works department of that city. The Cincinnati Bureau of Municipal Research is best known today by reason of its investigation of Cincinnati's paving contracts and specifications and has done work of scarcely less importance in improving that city's street lighting. The Bureau of Municipal Research in New York reports a long list of results obtained in engineering fields. A few may be cited:

“Cleaning of sewer basins lowered in cost from \$4.17 to \$1.90 per basin, by standardizing services.

“Reduced cost of cleaning public markets and public buildings.

“Reorganized administration of public baths.

“Instituted system of inspection and repair of municipally owned buildings.

"Secured, by reorganizing the division of inspection of sidewalk incumbrances, more than double the amount of work performed the preceding year by a force three times as large.

"Enabled recovery of more than \$700,000 from street railway companies for paving done at public expense between the companies' rails.

"Enabled the water department in one year to pump $2\frac{1}{2}$ per cent. more water at 25 per cent. less fuel cost than in the preceding year.

"Brought about a perpetual increase of \$2,000,000 a year in water revenues due to improvement in service and equipment of the water register's bureau.

"Scientific specifications instituted for purchase of supplies, and a standard sample room established to test deliveries.

"Designed and installed for the department of public works a system for paving inspection; a system of cost accounting records, making available unit costs for repairing pavements and for new repair work in public buildings, baths, comfort stations, etc.; and a detailed system for control over use of supplies within the department."

Our Bureau at the University of Texas has published three bulletins on engineering subjects (*Methods of Sewage Disposal for Texas Cities*; *Street Paving in Texas*; *Public Service Rates in Texas Cities*) and has a study of the public utility question practically ready for publication. The Municipal Reference Bureau of the University of Kansas has worked even more deeply into the utility affairs of that state. Instances might be multiplied, but one more will suffice. This is from a recent unprinted report (1915) of one of the newer research bureaus in a comparatively small city (some 75,000) in the Middle West. It is quoted at some length because in origin and nature it may be taken as a typical description of the work and results of the modern bureau of municipal research as that work affects the municipal engineer.

"Among the first investigations of public works," says this report, "was a study of the new water works system. The demand for an additional bond issue to be voted on seemed to

warrant a complete statement of the project—legislation, bond issues, construction contracts, etc.—in order that the public might have proper information as a basis for voting.

“Following that statement a report was issued showing the intended distribution of the successful bond issue of \$600,000. A study was made of the need for main extensions and reinforcements, resulting in an agreement to reduce the former item \$35,000 and the latter \$38,000, so that instead of spending a total of \$191,000 the department agreed to postpone the expenditure of \$73,000.

“At the beginning of the Bureau’s work the city had under construction, by order of the State Board of Health, a sewage disposal plant. Due to a stringency in the money market following upon the opening of the European war, and as an effect of a court decision relating to bond issues for such plants, the bond buyer refused to take all of the \$446,000 issue he had purchased. Hard upon that condition came the consulting engineer’s second increase in the estimate of the cost to build the plant. Initial approximate estimates had grown from \$350,000 for a complete plant to \$446,000 and finally to \$553,000. The bond issue of \$446,000 was therefore not enough. The particular question studied was that of the means by which the city could get a plant able to provide ample sewage facilities for some years, and at a total cost not to exceed the original bond issue. Facts placed before a special committee of the Chamber of Commerce led to a series of conferences with city and state officials, the contractor, and the engineer, resulting in a final reduction of \$107,000, thereby making unnecessary any additional bond issue to complete the plant.

“In order to prepare for collection of garbage, the Bureau assisted council and the service department in a study of that problem. On the basis of the report submitted, the present contract method of collection was adopted and the appropriation to cover the cost of collection decided. The Bureau assisted also in preparing the specifications and the contract for bidders.

“The Bureau, with the consent of the service director, undertook a survey of the needs of the bureau of street repairs. With

the assistance of an expert paver, the pavements were inspected and every break, depression or hole that needed attention within a year was noted, measured, and the cost of repair estimated. It was found that with six gangs and two or three teams the pavements of the city could be reasonably well repaired. The discovery was also made that sufficient funds were in the city treasury to pay for the entire program of repairs. This program was adopted by the department and much progress has been made. Unit cost records were also installed, and a beginning made toward obtaining the much desired information of the cost per square yard of street repairs.

"Following upon the survey of repairs, the Bureau took up the use of teams in the division of streets. The discovery was soon made that the superintendent has long been using his own teams in city work under the names of other persons; also that the names of individuals who owned no teams and who never did work for the city were being used as a cloak for the real owners of teams—viz., the superintendent of streets and his brother. These facts were brought to the attention of a special committee of the Chamber of Commerce, who took up the matter with the service director and the mayor. The ultimate result was the requested resignation of the superintendent of streets and the holding of an examination to fill the vacancy. Following the Bureau's work, the state conducted a public hearing covering the same ground.

"A survey of the bureau of street cleaning was begun and continued, each street being measured to determine the total area cleaned. The necessity for this detailed work was due to the fact that the engineers used wrong widths of streets in determining rates; that streets where sweeping was not done were being carried on the assessment roll; that inspection was utterly inadequate; that, if contractor's statements of the number of men employed were true, sweepers were obliged to clean daily from 4,500 square yards to 31,500 square yards, the one amount too small, the other a physical impossibility; that disproportionate rates were charged, that sweeping the same unit area (10,000 square feet) cost from 13 cents to \$1.39; and that other equally defective conditions existed. The above report was released to the public in whole thru the newspapers and in part thru the Bureau's bulletin.

"Growing out of the investigation of the use of teams came the request for a co-operative survey of the organization of the entire sewer department. A careful study and analysis was made of all records, and conferences were held with each of the division and bureau heads in the department. Statements of findings were submitted to each official involved, with request for correction as to fact; and from these and the many valuable suggestions received a complete report was drafted and submitted to the director and finally adopted in practical entirety."

If municipal research closely concerns the municipal engineer because it applies to his work, there is a still closer bond due to the nature of research. It has already been pointed out that municipal research is the systematic search by trained investigators for the unbiased truth in municipal affairs. The absurd part of it all—or rather it would be absurd were it not such a sad commentary on our attitude toward government and public affairs—is that this should be anything out of the ordinary. What is scientific research but the systematic search by trained investigators for the unbiased truth in matters of this or that science? What is experimental engineering, but the systematic search by trained investigators for the unbiased truth in matters of engineering? Yet after all these years we are just beginning to recognize the fact that the same fundamentals underlie progress in government. Prior to the inauguration of the municipal research movement, inquiry into municipal affairs was not systematic. It had not become a field of action for trained workers. It was not even free from the bias of conflicting selfish interest and the bias of partisanship. This revolt from bias to impersonal inquiry, from erratic and spasmodic action to orderly and rational procedure, forms the principal bond of sympathy which the writer believes is to tie the municipal research movement closely to the engineer. The events of the past ten or fifteen years have done much to raise municipal government out of the class of high-school-debate subjects. The day is passing when we argue in glittering generalities that one "form" of government is "better" than another, or this brand of administration "better" than that. We are beginning to see that each condition must be analyzed to its factors, each fact to its elements, and decision made in each case

on the merits of the case, just as critically and dispassionately as you would determine the cross-section of a plate girder to hold up under a given stress—and with just as wholesome fear of the results of miscalculation. It is in view of these facts and tendencies that the writer sees in municipal research merely an extended application of engineering principles.

There is a third line of close relation between the engineer and the movement, introduced by the state-wide bureau of municipal research. In its original conception, municipal research was essentially only for large cities. The expense of organizing and maintaining a staff capable of rendering service adequate to the usual need is greater than may be reasonably expected from a city of less than 50,000 inhabitants. The pressing needs of the smaller municipalities soon led to arrangements for rendering research service on contract. The New York Bureau of Municipal Research, for instance, regularly undertakes surveys and investigations of varying scope in other cities, and charges for the service its actual cost. But this arrangement is not sufficient for the needs of the small municipality. Work done on contract in this fashion can cover only special problems, and these only from time to time. There is no way of purveying the constant vigilance, the patient, continuous study of activity, that experience has shown is the least spectacular but most stable and in some ways most essential part of the program of a bureau of municipal research. To put it tersely, a successful bureau must be "on the job" all the time.

Further, the small number of towns and small cities that have availed themselves of these contract services gives evidence that few such places are able or enterprising enough to take advantage of that kind of arrangement.

In addition, if there be one message in all this paper that shall stick in memory, let it be the reminder that America's biggest municipal problem today, with the possible exception of the special problem of the congested metropolis, is the town and small city problem. The municipalities of 50,000 population and less outnumber the larger cities 20 to 1, even when we exempt from the former class all the incorporated places of 2,500 or

less, which, if included, would swell the proportion to over 140 to 1. Counting them all, the municipalities of 50,000 and less total as great or a shade greater per cent. of our total municipal population, as compared with the group of larger cities. The smaller municipalities, furthermore, are governed under the hardest conditions. Our clumsy laws, with their cumbersome details, their lack of flexibility, their attempts at classification, their tradition against administrative discretion, have discriminated against the smaller municipality, unintentionally but effectively, more often than not. Too, there are certain fixed charges of government. That is, as time goes on and municipal government develops and its functions become standardized, there appears an increasing total of expenditures that all cities must undertake, without much regard to their population. These are analogous to a fixed charge; for, while they are by no means the same for every city they are much more nearly so than municipal revenues, which, based as they are on taxation, vary more closely with population. The result is that the small municipality rarely operates at a time when it is not pinched for money. And not only are the small cities' resources less, but their administration is handicapped because of the lower rank of ability of the average city official of the smaller city. For keen municipal problems, first the metropolis; second the small town.

With these things in mind, consider the dearth of assistance at the hand of the small town. Scores of books have been written about the metropolis. The mayor of a town of 5,000 can read far into the administrative details of New York and Chicago and Philadelphia, and find many a shining and many a horrible example of things his city must or must not do in order that when it comes to have a few hundred thousand population it may be a nice city; and the advice is all good and most of it worth following. But he will find precious little that will guide him in the wise shaping of his own administration for best immediate returns. Or again, he may find outlined a complete system of metropolitan finance; but he is likely to look in vain for suggestions for the simple accounting system that he knows he needs but does not know how to install. He may find learned discourses on the three-platoon system; but scattered and few are sugges-

tions as to how he should dispose to best advantage his three-man force so as to break up petty thieving, browbeat speeding motorists, handle the Saturday traffic on Main street, keep peace in the saloon district, and combat the commercialized vice that drifts into town over Sunday. So we might go on. It seems as tho the collected results of our municipal studies so far are of minimum use to the class of municipalities which, because they are least able to help themselves, are in most need of help. Perhaps this explains why the idea of mutual self-help, of co-operation toward progress, of state-wide municipal research, has gained such headway in the past few years.

Fostered by the State universities in Wisconsin, Kansas, Texas, Illinois, Oklahoma, Minnesota, Alabama, Oregon and Washington; by other collegiate institutions, as Princeton in New Jersey and Whitman College in the Pacific Northwest; and sometimes independently, without any special fostering (as in California, Iowa and New York), state leagues of municipalities have been formed in nearly half the states. Their purpose is co-operation in the study of common problems, and in some progressive cases also in administrative action. By holding annual conventions, and usually by issuing publications, they facilitate and encourage the interchange of ideas and experience. Thru them their member cities present a united front in securing or opposing legislation. This much applies to practically every state league of municipalities. The further progress of a few of the vanguard shows the path that within the next few years the majority doubtless will have followed. The first step is co-operation in investigation. The cities that form the membership of the New York State Conference of Mayors and other City Officials (if we may take New York as a prominent example) have organized thru that association a "bureau of municipal information" much after the order of some of the research bureaus already described, with a capable director and a small group of assistants. The little force spends practically its entire time in securing and assembling information for the benefit of the supporting cities. A city is outlining a white-way project: what are the lighting costs in other cities? The question is put to the bureau for determination. What are the provisions of the most successful sewer-connection ordinances? What kinds of street

paving are in service and how much have they cost? What are the water rates in other cities? What types of refuse incinerator are in operation in other cities, and with what success?

So the questions come. The individual cities profit much by turning over this work of inquiry to the central organization rather than doing it themselves: for the city is relieved of the trouble; there is no duplication of effort and expense such as has been caused by two cities carrying on the same inquiry independently; the work is better performed, for it is in the hands of people whom experience has versed in the technique of securing information; the information obtained is available to all the cities, and its existence and availability is known to all the cities, instead of being buried in the files of one city while others are unconscious that the data have been collected. What is most important, the information is put within reach of the small municipality, which if left to itself could not afford the time and energy necessary to secure it. A service of this kind soon covers every phase of municipal activity, but the proportion of inquiry into matters of engineering interest is noteworthy. The city engineer who is alert to his opportunities makes constant use of his league of municipalities. "It is certainly filling a long-felt want," wrote one Texas engineer recently, regarding our League's central information service, "among the engineers practicing thruout the state, who in most cases cannot have recourse to a large library yet must keep abreast of the times on many subjects."

This is important because it, again, presages a step still farther in advance. If co-operation in research is praiseworthy, why not also in construction? The proposal is stated by Dr. O. C. Ahlers, president of the Texas Town and City Planning Association, in this succinct fashion:

"Perhaps fifty towns or cities in Texas are considering some water supply problem; thirty expecting to enlarge their plants and twenty expecting to institute an original system. If all these could furnish a central office with the proper definite information as to the extent of their contemplated expenditures and express a willingness to provide a certain per cent. for the expert advice, or plans, or survey and plans and superintendence, this compiled in-

formation could be taken up with such engineers as were available. 10 to 50 per cent. and these towns would have the advice of an expert who would perhaps not have considered any one of the contracts independently.

"A similar pooling of interests may be applied to other activities as they appear, as street service and ornamental lighting, elimination of grade crossings, surface drainage, sewerage and sewage disposal, parks, playgrounds and other recreational facilities, railway and other transportation facilities and particularly city planning."

With this in accomplishment and prospect, we may further note that there is another most interesting and most promising development transpiring thruout the states. I refer to the beginning of research in state government. That long neglected field of administration, involving the expenditure of so many millions of dollars, embracing so many matters of vital concern, is just beginning to be submitted to the same kind of scrutiny that has done so much for city government. In most cases the agencies are "efficiency and economy commissions," such as have been created in perhaps a quarter of the states. These are bodies appointed thru action of the governor or legislature to study the usually haphazard structure of the state and recommend reorganization that will enable the same work to be done for less money, or make possible more effective results from the same expenditure. So far, except in a few instances, their investigations and reports have dealt much more with structure and organization than with method and efficiency of administration. However, progress in the latter direction is coming from other sources. Some bureaus of municipal research (notably the Bureau in New York City, in connection with the recent constitutional convention) have delved deep into state administration. There has not yet been established any organization that definitely merits such a title as "bureau of state research;" but recently organized agencies of citizen inquiry bear such titles as "Bureau of State and Municipal Research" and "Bureau of Governmental Research," and indicate plainly that scientific inquiry into the conduct of state's business is to be a prominent part of their functions. To round out the whole, and give us a glimpse ahead into the results we may eventually hope for, there has been organized, with headquarters at Washington, a bureau whose purpose

is impartial and non-partisan scientific research into the business of national government.

This extension of scientific inquiry and scientific methods farther and farther among the cities and counties and into state and national government opens to the engineer the possibilities of a new profession. The large proportion of governmental affairs occupied by matters of engineering and public works demands that a large part of government research be put into the hands of experienced engineers; for experience is one of the most necessary prerequisites to sound judgment. If this were universally done in the various fields into which municipal research workers go, the most valid objection raised against municipal research would be silenced. Much outcry has been raised against municipal research, ever since the days of the Ahearn investigation ten years ago, when Tammany Hall set out (unsuccessfully) with a brass band, an elephant and a cage of monkeys to deride and discredit the "Bureau of Municipal Besmirch," as they dubbed the little band of pioneer investigators. The outcry has taken many forms, but most of it comes from officials and subordinates whose work has in some way been unfavorably criticised, and is to be taken with a large grain of salt—very large and very salt. There is this one valid criticism of some research work, however, that is justified, namely, that some of the investigators in the employ of the research bureaus are not qualified to appreciate the facts they seek nor interpret them after they have been found; that the "experts" whose recommendations form the bureaus' reports are "parlor engineers" and other equally inexperienced men; that their work is superficial, their conclusions are academic, and their recommendations worthy of but little consideration; that, as one administrator forcefully expresses it, "we fellows who have studied this sort of thing and spent our lives at it are stood around and told what to do by a bunch of clerks." There is much to be said on the other side of this question also. Much of this objection arises from personal pique. Much comes from the reactionary element that can see no wisdom but its own, that acknowledges no expert but itself. Neither can we have much sympathy with the public official who closes his ears to suggestions regarding his work, whatever their source. But where the complaint is justified, we may regard the condition as unfortunate

but temporary. Obviously a bureau of research that is incompetent can find but few to respect its recommendations, and a bureau of that sort will quietly perish before the law of the survival of the fittest—that same gardener that weeds out the private engineering profession and every other profession. Meanwhile there is all the more evidence of the opportunity in governmental research for the experienced engineer who is otherwise qualified for that work.

Nor are municipal engineering and public works the only departments for research that lie open to him. We have pointed out that governmental research is practically an application of engineering methods to the affairs of government. Who is better qualified for the broad work of directing research than the man of engineering training? Our public affairs, some of us think, have been too long in the hands of lawyers, who are tied to precedent, committed to technicalities, and trained to take sides arbitrarily rather than appraise a whole situation at its true worth. In municipal administration we are swinging more toward the engineer, who can be impartial, get at the principles of things, and work efficiently. Witness the city managers. As Mr. J. L. Jacobs recently pointed out, speaking before the Western Society of Engineers, "Engineers, because of their analytical training, their ability to obtain and stick to facts and to act with precision, their imagination and vision for new and big things and their genuine interest and spirit of public service, have in the public service almost a virgin field." This, unfortunately, is an enthusiastic overstatement, and the fact is that so far it is the exceptional engineer, rather than the member of the rank and file, who has shown exceptional vision or interest in the public service. But it hits the nail on the head in pointing to the engineer as the man best fitted by training and turn of mind for the public service. How much more, in proportion, do we need the man of the same turn of mind in the all important tasks of governmental research, the trail-blazer for the administration of tomorrow.

The man who is simply an experienced engineer, however, or even an experienced municipal engineer, is no more fitted for municipal research than a professor of political science would be to test paving materials. The man who succeeds in municipal research must be an expert in his particular profession and must also

have a sound conception of municipal government; just as the man who is to install a system of scientific shop management must be a master, not only of his system, but of the shop and industry in which his system is to be applied. The average engineer does not possess this mastery of municipal government. The part the engineer has played in the administration of government has been for the most part one of honest, self-sacrificing service, a bright spot in the history of administration. Mr. Morris L. Cooke, addressing the Engineers' Club of Philadelphia last January, was able to say, "I am told by municipal researchers that taken the country over no other class of officials have a better record for probity or the painstaking execution of public trusts than have our municipal engineers." But, as Mr. Jacobs further points out in the paper already referred to, the role which the engineer has played in the administration of public affairs has been mostly that of close applications to *details* of administration. Naturally the large point of view has not developed. This is why, tho opportunity awaits the engineer in municipal research already, it is not comparable with the promise that the same work holds for the engineers of the next generation; provided, that is, the scope of engineering education is broadened adequately to give the outlook that a leader in public affairs must have.

What chance is there of expecting unbiased judgment on public utilities from an engineer whose viewpoint has been shaped by schools, engineering societies and a technical press largely influenced, consciously or unconsciously, by the utility interests? What inspiration is there for public service in the doctrine, too often injected into the channels of engineering education, that municipal governments are unsavory, a necessary evil, to be shunned by honest men and entrusted with as few functions as possible? Fortunately the interests that have promoted this tendency, tho highly organized and vigorously active, are a minority group and their strength is waning. More formidable than these positive deficiencies are certain negative ones. The hindrance imposed between the engineer and the public service is not so much force as inertia. Taking the profession as a whole, engineers have paid too little attention to the larger aspects of public affairs. How many engineering schools include among their courses instruction

in municipal government, or in any other branch of government or political science?

Mr. Folwell is now able to print each week in the *Municipal Journal*, a third of a page or more under the caption, "Problems That Cities Are Studying with Experts"—instances of the public's increasing confidence in the professional specialist. Truly this is a healthful sign after the many years in which every man on the street corner was an expert in every question that concerned the government. Must it be said that as yet the majority of engineers have not grasped the conception of their corresponding duty to the public?

Looking to the future, then, the engineering profession should encourage broad education that will equip for public leadership. For the present, as the long step toward the unity of action that evidently is so opportune, we must foster constantly closer co-operation between the city engineer and the bureau of municipal research; not the kind of co-operation that consists merely of tolerating the research worker in the engineer's office when his work takes him there, of furnishing the information he asks for, and of at least reading his report when he submits it; but active co-operation born of close sympathy with the purposes of municipal research and the desire to give toward their achievement the aid that only an engineer can give.

DISCUSSION.

NORMAN S. SPRAGUE: If it is in order to discuss the paper which has just been read, I would like to make a few remarks. I have no quarrel with the different bureaus of municipal research. I am very much in favor of research, as such. It has been said that the public are entitled to no better government and efficiency in their government than the men whom they elect to office are capable of giving them.

Now these different bureaus of municipal research are all right in their way, but in my estimation they do not get at the fundamental causes of inefficiency or incompetency or graft, or whatever you may please to call it, which may exist in the management of municipal affairs. The greater part of the inefficiency, especially in the smaller

boros, towns and cities, is due to the people who are elected to office. They are generally honest and have good intentions, but they are not, in most cases, competent to formulate the necessary legislation which may be required in the solving of municipal problems.

If only a part of the research work and advice was directed and furnished to the officials who have the authority to make these laws and control and direct the policy of public works, it is my opinion that a greater benefit would result and more good be accomplished. It is very simple for a research bureau to go into any large municipal organization and stand off and criticize the system or the work and make recommendations for its betterment, but lose sight of the fact that it is a public matter with which they are dealing and that the representatives of the public have already decreed what the system or organization shall be.

There is no public official who has been in office any reasonable length of time but what knows better than anybody else what reforms or what changes toward efficiency are best for that municipality; but the official in most cases is powerless to make such changes. If the different municipalities, instead of employing research workers to investigate the efficiency of city engineers and other public works offices, would direct their attention toward the legislative branch of the government, greater benefit would result.

To inexperience and lack of training in public works by those in control can be traced some of the evils which are complained of, but the laws themselves are responsible for most of them. If research work or consulting advice is necessary for the boros, divisions and departments of municipal governments, that service should be rendered by the best authority upon the matters which are to be considered which the municipality can afford to engage.

I have known of instances where young men were employed by research bureaus and have entered municipal offices and advised upon all matters relating to the organization and activities of the various functions with little or no qualifications for such service. Such a practice is not only an insult to many a competent official, but is also a waste of time and money. When reform or greater efficiency is desired in the administration of public business many of the existing laws will have to be changed so as to make this

possible, and when that is done the public official can secure efficiency without any assistance. A study of legislation which now operates to prevent efficiency and good management in public office would be a profitable and worthy undertaking and it is right here that all research investigation should start.

MR. PAXTON: May I simply say a word in answer to the very good advice of the gentleman who has just spoken. In speaking, due to the very limited time which we had this morning, I talked about only one side of the work that has been done by these bureaus. A very great deal, especially in the state of California, has been accomplished by the State League of Municipalities, not only in agitating legislation which is necessary, but in blocking legislation that is harmful. And that is one of the prime purposes, I might say, aside from the mere comparing of experiences, which the State League of Municipalities has successfully undertaken. In some of the Eastern leagues of municipalities, especially in New York, and I think you will find it true in New Jersey also, that is perhaps the most important part of the leagues' work.

REPORT OF THE COMMITTEE ON FIRE PREVENTION.

Alcide Chaussé, Chairman, Montreal, Can.

On the 21st of February, 1916, Mr. Chas. C. Brown, the Secretary of the American Society of Municipal Improvements, wrote to the Chairman of your Committee on Fire Prevention, asking him, if possible, to attend a conference of association secretaries and others interested in fire resistive construction, at Cleveland, on the 26th of February, 1916. As the time was short for making such trip, I wrote to the secretary of the conference, expressing my regrets of being unable to be in Cleveland for that conference, and asking that I be sent a copy of the proceedings. From that report, I note that the conference was a success. This meeting was called for the purpose of learning the definite official attitudes of the various associations on the questions which were tentatively discussed at a previous conference. These questions are outlined under the following headings:

First—Reports from the association, giving their official attitude regarding co-operation among the industries.

Second—The consideration, and possible adoption, of the constructive program, which was also discussed at the first conference, namely:

(a) Adoption of the principle of classification of buildings in accordance with fire resistive qualities.

(b) The amplification and extension of tentative tables of test specifications for materials of construction, established by the International Fire Prevention Congress, held in London, England, in 1903.

(c) Co-operative effort to secure a large extension of the work of the Bureau of Standards.

(d) Co-operative work among industries, looking toward the formation of a basic, fundamental building code.

Third—The selection of committees drawn from the industries to work upon the various phases outlined in the constructive program should this constructive program be adopted.

The report of the proceedings of the conference, which I leave with the Secretary of the American Society of Municipal Improvements, for future reference, as well as the various letters received from the secretary of the conference, can be consulted by anyone interested in this matter.

The Building Inspectors' Conference was, this year, held in Chicago in combination with the annual convention of the Concrete Institute, the Cement Show and special tests made by the Underwriters' Laboratories.

The program of the Building Inspectors' Conference was as follows:

(1) A review of the past year, including progress in code writing and revision, notably in New York City, including also an account of important fires.

(2) Discretionary power of building officials—its proper limits and use.

(3) Building code requirements for special building materials, such as gypsum blocks, hollow tile, terra cotta, metal lumber and metal lath.

(4) The shingle roof.

(5) Classification of, and requirements for lodge halls; also rooming houses.

(6) Other suggested topics to be added as time permits; such as limits of height and area; distinction between building and fixtures, including wooden dwarf partitions in fireproof buildings; licensing and bonding contractors; organization of a building department.

The cities of New York, Minneapolis, St. Paul, Duluth and Cincinnati were reported as revising their building regulations.

The general consensus of opinion on the question of the discretionary power of building officials was that it was generally exer-

cised, and should be recommended, so long as in the use of such power the general intent and purpose of the building regulations was adhered to, and the following resolution was unanimously adopted:

That discretionary powers should be vested in building officials to vary or modify the law, where practical difficulties arise in the literal enforcement, so that the intent of the law is secured; and, that in case the building official declines to exercise such discretionary powers an appeal should lie to a board of technical experts.

The formulation of standard specifications for hollow building tile and construction was outlined. Metal lumber and metal lath were also given attention, and particular information was sought concerning the fire test of metal lumber made at the Greenpoint testing station by Columbia University for the city of New York, on April 14, 1915. The more uniform recognition of gypsum block or tile as a fire-proofing material in keeping with the required standard for such construction as covered by the 1915 building codes of the National Board of Fire Underwriters and the city of New York was conceded as desirable.

There was a lively discussion on the question of encouraging the total discontinuance of the use of wood shingles, or restricting their use to territory outside of any prescribed fire limits. There was considerable diversity of opinion, but in general the sentiment seemed to favor the restricted use of shingles upon a limited class of buildings and always outside of any prescribed fire limits.

The theater and lodge room exit requirements, seating capacity, class of construction, etc., were fully discussed, resulting in a resolution being adopted as follows:

That proper means of egress from every building should be provided in the form of enclosed stairways; that outside metal fire escapes should not be considered as a required means of egress from new buildings, and that their use should be confined to existing buildings where other means of egress are impracticable; and, that, wherever such fire escapes are used, the openings thereon should be protected by metal sash and wire glass or by fire-resisting doors with proper fusible links.

There were no resolutions adopted on the other subjects before the meeting.

The organization was made permanent under the name of "Building Officials' Conference" and will consist of active, associate and honorary members.

The resolutions adopted by the National Fire Protection Association at its annual convention held at Chicago, in May, last, are as follows:

The National Fire Protection Association, assembled in Chicago for its twentieth annual meeting, calls attention to the disastrous fires of the past few months which destroyed whole sections of cities in the South and elsewhere and which further emphasize the need for better building construction and the avoidance of wooden shingle roofs and other combustible materials in the exterior of buildings.

The association heartily commends the growing movement for city planning as likely to produce better conditions as to building heights and congested areas, and provide the open spaces and broad avenues, which, beside their human and esthetic values, are excellent checks to sweeping fires.

In its warfare against the needless sacrifice of human lives and property by fire, the association advocates the following measures:

1. The adoption by municipalities of the Standard Building Code of the National Board of Fire Underwriters to the end that fire resistive building construction may be encouraged, the use of inflammable roof coverings prohibited, adequate exit facilities from buildings assured, and interiors so designed and fire-stopped as to make easy the extinguishment of fires therein.

2. The adoption by all states of minimum building requirements for the protection of state and county hospitals, asylums and similar institutions outside city limits and of small communities in which the establishment and enforcement of a building code is impracticable.

3. The enactment by each state of the fire marshal law advocated by the Fire Marshals' Association of North America to the end that official investigation may be made of the cause of all fires, preventable fires may be eliminated by public education, and the crime of arson stamped out.

4. The adoption of the association's suggested ordinance providing for the systematic inspection of all buildings by city fire marshals or local firemen to insure the vigorous enforcement of rules for cleanliness, good housekeeping, and the maintenance of safe and unobstructed exits, fire-fighting apparatus and other protective devices.

5. The enactment of ordinances similar to that of Cleveland, O., fixing the cost of extinguishing preventable fires upon citizens disregarding fire prevention orders, and a more general legal recognition of the common law principle of personal liability for damage resulting from fires due to carelessness or neglect.

6. The wider general use of the automatic sprinkler as a fire extinguishing agent and life saver and the more general adoption of the fire division wall as an important life-saving exit facility.

7. A careful study of the technical surveys of cities made by the engineers of the Committee on Fire Prevention of the National Board of Fire Underwriters covering the items of water supplies, their adequacy and reliability, fire department efficiency, fire alarm systems and conflagration hazards; and of the possibility of co-operation among neighboring cities thru mutual aid and the standardization of hose couplings.

8. The adoption of the association's suggested laws and ordinances for state and municipal regulation of the transportation, storage and use of inflammable liquids and explosives.

9. The universal adoption and use of the safety match and legislation prohibiting smoking in all parts of factories, industrial and mercantile buildings except in such fire-proof rooms as may be especially approved for the purpose by fire departments.

10. The education of children and the public generally in careful habits regarding the use of fire.

11. The co-ordination of all these activities thru a central administrative officer or body of the state or city having primary jurisdiction, for the purpose of promoting uniformity of active and efficient co-operation.

In the furtherance of these objects, we appeal for the co-operation of all citizens. We ask them to help in the dissemination of our valuable literature and in the use of the standards of fire protection so carefully worked out by our committee to the end that the lives and substances of our people shall not continue to be dissipated by a reckless and easily preventable waste.

The question of uniform boiler specifications and laws, mentioned in Mr. J. C. McCabe's communication to the convention at Dayton last year, has led to a lengthy correspondence between the Chairman of your Committee on Fire Prevention and The American Uniform Boiler-Law Society. Mr. McCabe has been requested to bring this matter again to this convention. I leave with the Secretary all the correspondence and literature received on this subject for reference.

The celebration of October 9 as Fire Prevention Day was more general in 1915, and on a more elaborate scale, than ever before. Fire marshals of the various states conducted much more general campaigns in favor of the observance, and reached many more classes and wider interests than has been done in any other year. The Safety-First Federation of America took an active part in the movement this year, for the first time, and as this is a national organization, with ramifications in many states, where there are no fire marshals, and among many interests which are not reached by these officials, many new factors were brought into the observance.

The state fire prevention associations also were unusually active, and local organizations of fire underwriters, of credit men, and, in some cases, the city fire departments, bore important parts in making the celebrations more general and a greater success.

Every official and citizen interested in the reduction of fire waste and consequently in the success of Fire Prevention Day, should obtain all the publicity possible for the fire prevention idea at or near the time of October 9. If a cleanup campaign is inaugurated, it will be easier to concentrate all display publicity on the one idea of fire prevention. The practical work and the publicity should go hand in hand—real accomplishments with publicity and real publicity for a workable program.

UNIFORM BOILER LAWS.

By J. C. McCabe, Chief Inspector Engineer Department Safety Engineering, Detroit, Mich.

No doubt, you are all acquainted with the movement now being fostered by the American Society of Mechanical Engineers for a uniform adoption thruout the United States of the boiler code formulated by that society.

No doubt, it will appear very strange to those of our members who have taken up engineering practice in the past generation, that a reasonable and practicable standard has not already been established for matters relating to steam boilers.

The steam boiler is, without doubt, the very heart of modern industrial conditions and advancement. Were the steam boiler to be discarded today, notwithstanding the advancement of the internal combustion engine and hydro-electric power plants now in operation or in prospect, our industries would be paralyzed. The steam boiler is very much in the position of the eldest son of a large family, who is compelled to go out to work early and support the numerous progeny of his industrious parents (Industry and Necessity), and slowly obtains sufficient time to receive such an education, training and refinement as eventually come with time and opportunity.

Those of us who have reached the age of fifty years, or thereabouts, will remember, about a generation ago, that we had two standards for half-inch machine threads; one, 12, and the other, 13; and the frequency with which he endeavored to put a 12-pitch machine bolt in a hole tapped 13, or vice versa. Similar instances were common. The natural result was the standardization which has brought about the great prestige now enjoyed in most of our industrial lines today.

The boiler manufacturer, today, is in pretty much the same position as was the oyster-opener at a local hotel in Detroit, some years ago. The hotel in question was operated by two brothers, Jim and Willie. They being equal partners in the business, their

authority was not clearly defined. On one occasion, Willie directed the oyster man to not place his oyster bucket on a newly-laid floor, because of the moisture exuding from the bucket; but that he should place the same on the zinc-covered table on which the oysters were opened. A few minutes afterwards, Jim came along and made violent protest against the placing of the bucket on the table—this for sanitary reasons. The oyster man informed him that he placed the bucket on the table by Willie's order.

"Never mind what my brother said," declared Jim. "Put the bucket on the floor."

About a half hour later, Willie came along and saw the bucket on the floor, and exclaimed:

"Gol darn it, didn't I tell you to keep that wet bucket off the floor? Why don't you do what I tell you?" The oyster man replied:

"Your brother told me to keep it off the table."

"Never mind what my brother says," declared Willie. "You do what I tell you."

The result of these divisions of authority and diverse views as to where the bucket should be placed was a severe strain on the oyster man, as he nearly became cross-eyed watching for Jim and Willie, and was uncertain as to whether the bucket should be on the table or on the floor.

The foregoing actually occurred, and is an exact parallel of the perplexity surrounding the boiler inspector today, because of the various rules and interpretations placed upon existing boiler laws. The law sharks tell us in one breath that the law must be enforced as written; and in another breath, they tell us that if its provisions are unreasonable, it cannot be enforced. And in many instances, the inspector himself is pretty much in the same position as the oyster-opener, and the manufacturer is placed in the position of the oyster. It requires no argument to prove that boilers should be built from suitable materials, and so designed as to introduce the least possibility from failure, both from direct loss and internal strains that may be engendered because of their design.

The present tendency in engineering practice, as it relates to

steam boilers, is to demand a much greater output. It naturally follows that this means excellence of design, the highest possible furnace temperature and the lowest temperature of up-take. That is, the facts make it imperative that a steam boiler must have excellent design, material and workmanship, if it is to stand up under the severe conditions now being demanded from steam boilers.

It is to be regretted that a small percentage of boiler manufacturers today, placing steam boilers on the market, are not fully educated up to their responsibilities to the public. Many of them, in the small percentage mentioned, are not properly equipped to turn out a safe and proper boiler. Instances have occurred under my own observation where plates have been cracked in the shop because of heavy blows used on the plate to form them. The steam boiler should be followed by a responsible inspector from the material in the warehouse up to its final installation when it is ready for use, and see that all the essentials for safety are complied with.

The code of the American Society of Mechanical Engineers provides all these essentials for uniformity thruout the country, and safety and reasonableness in the manufacture of boilers. Under the provisions of the A. S. M. E. code, a boiler made in any section of the country may be re-located and used in any other section. This code will prove of inestimable value to contracting engineers, who are called upon to send their apparatus to various sections of the country, within comparatively short periods of time. It will surely raise the standard of manufacture, and at the same time reduce the cost of the same, because the manufacturer will not be restricted in the manufacture of boilers, as is the shoe-maker, who, naturally, is compelled to measure the feet of his customers before he can make a shoe to fit.

It has been the observation of the author that the various conflicting regulations existing thruout the country have not been enacted because of any vicious intent on the part of their framers, but are only indications of local opinion as it relates to steam boilers.

I am certain that every city and state in this country will, within the next two years, waive all personal opinions and views and accept a common standard for steam boilers which is based upon the experience and knowledge of our best equipped engineers.

I would respectfully ask this Society to formally approve the A. S. M. E. boiler code, and send a copy of the same to Mr. Thomas E. Durban, Chairman of the Administrative Council, who is charged with the promotion of this code thruout the United States; both in behalf of the American Society of Mechanical Engineers and public-spirited manufacturers who are lending their time and energy to this movement, which will benefit all classes of society.

MY EXPERIENCE WITH COST DATA IN MUNICIPAL WORKS.

*By Paul-E. Mercier, Chief Engineer and City Surveyor,
Montreal, Que.*

The writer's intention in presenting this paper to the members of the American Society of Municipal Improvements, is not to emphasize the results he has obtained as much as to raise suggestions, advice and criticisms on the system he has established.

If this paper helps some junior members, who may find themselves in the same predicament as the writer was, in 1914, or if some members, having been in the dark as to the cost of certain works and succeeded in establishing reliable cost data, will help the writer by their criticisms, the value of this paper will be proved.

In 1914, when the writer joined the city forces, he found that he could determine the cost of a sheet asphalt pavement per yard, by dividing the total expenditure, as shown by the accountant's books, by the total yardage as measured on the streets. The same valuable information was obtained for brick and stone pavements, also for sewer work.

This was, therefore, done for work carried out by the city forces. The cost per square yard was found to be \$2.79 for the following: 1-inch binder, 2-inch wearing surface on a 6-inch concrete foundation, 1:3:6 mix and including the grading.

The contractor's price for the same class of work was \$2.40.

This cost was as astonishing to the writer as it may be to the members of this Society.

Before going any further, the writer must here explain the organization of the city work.

The city was divided into three divisions: East, West and North, each having approximately the same area and the same mileage of streets. Each had its own asphalt plant, yards, store and office,

and field organization, under a superintending engineer, who had to report to the Chief Engineer, then the late Major Janin.

The following asphalt plants were at the city's disposal:

Division	Plant Built Year	Daily Capacity Yards	Cost
East	1908	1,000	\$16,000.00
West	1909	1,500	22,000.00
North	1914	2,000	28,000.00
Spare Plant Portable	Purchased by City 1914	1,500	26,000.00

The city also had the necessary plant and tools for the construction of any pavements.

The writer found out that he could establish the cost and the quantity of the material used in the construction of pavements.

To save time, the writer will in this paper consider mainly the sheet asphalt pavement, but his remarks on this kind of pavement will also refer to any other pavement and sewer work.

The wages and cost of materials for 1914 were as follows:

Bitumen—\$26.00 per ton f. o. b. plant.
 Sand—\$1.00 f. o. b. plant or works.
 Stone—85c-\$2.00 per ton f. o. b. plant or works.
 Flux—10c per Imperial gallon, f. o. b. plant.
 Cement—\$1.66 per barrel.
 Laborers—22½c per hour.
 Teamsters—57½c per hour.

The writer tried to locate the leaks, but felt like a diver working in a sea of India black ink.

He, therefore, memorized the prices paid for material, the cost per square yard of work done, and studied the organization of labor.

During the winter months of 1914-1915, several conferences were held with the engineers and superintendents, and finally tenders for materials were called for, giving the following results:

Bitumen—\$14.25 per ton f. o. b. plant.
 Sand—75c-98c per ton, f. o. b. plant.
 Stone—\$1.10-1.70 per ton f. o. b. plant or works.
 Stone dust—\$5.45 per ton, f. o. b. plant.

Flux—10 $\frac{3}{4}$ c per Imperial gallon.

Cement—\$1.71 per barrel, f. o. b. plant or works.

Wages were increased—

Laborers—25c per hour.

Teamsters—60c per hour.

A cost-data system was established and we discovered, much to my satisfaction, that the cost per yard of sheet asphalt had been reduced to \$2.13 per square yard, being a reduction of 23.65 per cent. on the work done in 1914.

The cost of work was divided into three main items—grading, foundation and surface. Each item was subdivided into labor, material, sundries. The subdivision called sundries included the following: Engineering, displacement of poles, pipes and underground system, legal expenses, repairs of and interest on plants, tools, etc. The bookkeeping was closely followed and we had the following information:

	Percentage On Total		Cost Per Yard, Cents		
	<i>Grading.</i>				
Foremen	1.145		2.4327		
Timekeepers .....	.065		.1166		
Engineers .....	.073		.1590		
Layers .....	.022		.0477		
Drillers .....	.032		.0689		
Water boys .....	.034		.0742		
Watchmen .....	.903		1.9188		
Laborers	12.693		26.9240		
Teamsters	8.273	23.240	17.5536	49.2953	
Material					
Sundries .....	.192		0.4081		
Repairs, Int. etc..	1.551	1.743 24.983%	3.2913	3.6994	52.9947c
	<i>Foundation.</i>				
Foremen .....	.768		1.6340		
Timekeepers .....	.053		.1140		
Engineers .....	.308		.6555		
Layers .....	.013		.0285		
Watchmen .....	.894		1.9000		
Laborers	5.482		11.6565		
Teamsters	6.171		13.1195		
Autos .....	.018	13.707	.0380	29.1590	
Stone	7.659		16.2830		
Sand	7.083		15.0575		
Cement	13.092	27.824	27.8350	59.1755	
Sundries	1.068		2.2705		
Repairs, Int. etc..	2.073	3.141 44.682%	4.8080	7.0785	95.4130c
	<i>Surface.</i>				
Foremen .....	.286		.5873		
Timekeepers .....	.051		.1097		
Engineers .....	.302		.6454		
Spreaders .....	.670		1.4263		
Tampers .....	.375		.8003		
Watchmen .....	.193		.4181		
Laborers	1.359		2.8913		
Teamsters .....	.333		.7099		
Autos .....	.594	4.163	1.2849	8.7839	
Material					
Asp. bin. & wear.	24.543	24.543	52.2193	52.2193	
Sundries .....	.696		1.4844		
Repairs, etc. ....	.933	1.629 30.336%	1.9878	3.4722	64.4754c

We found that the cost of this pavement was still too high. Each item was studied carefully.

The grading was rather an indefinite expense, varying with each location.

The cost of the surface was carefully gone into and found to be fair.

The cost of the foundation was considered too high and the leaks were located and carefully sealed.

During the winter months a cost-keeping system and a time-book were devised.

Each page of the time-book is headed with the date of the last day of the week, the nature of the work, the location. Each page is divided into seven columns; in the first is the name and number of the employe; the second, third, fourth, fifth and sixth are subdivided into eight columns, one for each day and one for total hours; the last contains the total number of hours for the week. Columns 2, 3, 4, 5 are headed with the nature of the work, such as grading, foundation, surface and special; the sixth column shows the total time for each day.

Fig. No. 1 shows the time of John Hogg for the week ending September 10, and we find that he employed his time as follows:

Curb setting	19 hours	\$ 4.75
Grading	19 hours	4.75
Foundation	12 hours	3.00
Surface	10 hours	2.50
<hr/>		<hr/>
Total	60 hours at 25c	\$15.00

The total time for each work is reported on special sheets, which are shown in Figs. 2, 3, 4, 5.

We have, therefore, the actual cost for each of the items referred to at the beginning.

The Figs. 2, 3, 4, 5 refer to a certain work completed this year, and we find that the actual cost of that work was:

1896

1

1896

The staff is now familiarized with the cost data system and much interested in it.

At the end of the season, a list showing all the work done, the cost per unit and the name of the foreman, is sent to all the foremen for their information.

The sample sheets, showing one special work, will furnish the members of this Society with the details of the cost.

The writer hopes to receive suggestions which will help him to still further reduce the cost of this work.

REPORT OF THE COMMITTEE ON STANDARD FORMS.

A. P. Folwell, Chairman, New York City.

In conformity with the intention of this committee, as expressed in its report last year, it has devoted its energies this year almost exclusively to giving publicity to the units already adopted and endeavoring to secure a more or less general use of them by cities thruout the country. The units for street paving and for sewer construction were selected as those on which the committee should concentrate its energies, and considerable thought was given to preparing definitions of units which should be as brief as possible in order that they might all be placed on a single card convenient for handling, and at the same time making the meaning unmistakable so far as this was possible. Under the head of street paving, definitions were given of the units "pavement," "base," "excavation and embankment," "curb," "gutter," "sidewalk," "sidewalk base"; also "constructing sewer," "branches," "manholes," and "replacing pavement."

These definitions were printed on cards, those referring to street paving on one card and those referring to sewer construction on another, copies of which cards should have been received by every member of the Society. In addition to sending cards to the members, they were sent to more than 2,000 city and town engineers, superintendents of streets, etc., accompanied by a letter explaining the aims of the committee and requesting the adoption of the units. The committee is glad to be able to report that it has received scores of letters commending the work which it is doing. Most of these were from city engineers, and in all but two or three cases, these engineers reported their intention to adopt these units for use in their cities. About one-half of them stated that the units they were using were nearly, and in some cases exactly, the same as those advocated, and most of them stated that they would make the slight changes necessary for complete agreement with the Society's standards. Perhaps the most gratifying instance of this kind which was brought to the attention of the committee was that of the city of

Victoria, B. C., where Assistant City Engineer Foreman had developed a very complete system of collecting and recording cost units, some of the units, however, differing somewhat from this Society's standards; and he expressed his intention of making such changes thruout their forms and methods as would bring about complete conformity thereto.

In addition to city officials, our units have been officially adopted by the Granite Paving Block Manufacturers' Association, which "will join the American Society of Municipal Improvements in urging engineers, city officials, contractors and manufacturers to adopt and use these standard units for street paving." Secretary Blair, of the National Paving Brick Manufacturers' Association, writes that he is "fully in accord with this effort of the Society and will do what I can to encourage the employment of the units as set forth and I trust that everyone else will do likewise." The secretary of the Southern Paving Brick Manufacturers' Association writes that we may count upon the co-operation of that association in every way. In addition to this, several of the largest paving concerns in the country have agreed to do what they can to further the use of the units.

In the early part of the year, the chairman of the Committee read a paper before the annual Conference of Mayors and Other Officials of the State of New York, advocating these units, and the subject was made a special order for discussion by the society. As a result of this, this organization appointed a committee to consider the matter with a view to recommending the units for adoption by all the cities of the state. This committee secured copies of the definitions of these units and sent them to the engineers of every city in the state of New York, announcing the idea of the committee to request their general use, but asking first that the engineers send to it any criticism which they might have. Two criticisms have been received from these city engineers, which, together with those received from others, will be referred to in this report. The committee of the New York officials will probably meet within a week or two to take action on the matter.

Publicity has also been obtained in the technical press, most of the technical papers which deal with municipal matters having com-

mented favorably upon the units and recommended their adoption, some at considerable length. The daily papers also in a number of cities have published more or less on the subject, quoting from the paper read before the New York State officials, or from articles which have appeared in certain of the technical papers.

Among the comments made in letters received by this committee was one from a city attorney of a Kentucky city, asking for assistance in securing the adoption of the units in that city because he believed that "by following the method of receiving bids suggested by you, property owners will be enabled to understand more intelligently the cost of street improvements and their assessments for same." This idea of being able to show the property owners without long and probably misunderstood explanations why the paving in one street should cost more than the same kind of paving in another street, seems to us by no means the least important advantage of adopting a system of unit costs.

A city engineer in New England writes: "At the present time the published costs of city work do not have near the value they might have if made upon the basis of standard units." A member of the Montana Institute of Municipal Engineers had been working for the adoption of standard units by that society for several years, but "will be very glad to accept your units and will propose that our society adopt them for Montana." A city engineer in the state of Washington is "heartily in favor of the standard unit idea and would sacrifice any pet ideas of my own to conform thereto."

This last expression suggests one difficulty which the committee had anticipated in securing the general adoption of these units—that a number who had previously worked along these lines might have some pet ideas which they would not be willing to yield in favor of this Society's standards. We are glad to say, however, that there have been very few evidences of this, most engineers realizing that a uniformity in the units was of more value than any minor considerations connected therewith. The fact that approximately one-half of the several score of engineers who replied stated that the units they were using approximated more or less closely those recommended by the Society indicated to the committee that its choice of units was a wise one; it being our idea that we should

adopt such units as would conform as nearly to the practice of a number of the more progressive cities as possible and still give the desired results in the way of making possible a comparison of costs between similar work in different cities, and also permit a logical and effective separation of the total cost into unit costs.

The general adoption of these units having now assumed some momentum, it would seem to be the duty of every member of this Society to assist in the work of making them the recognized standard for the entire country, and we hope that every member will not only adopt them for his own city, but will endeavor to secure their adoption by all the cities in his vicinity, by city and other local organizations of engineers or other city officials, and by whatever means seem practicable.

A year's experience discussing the matter in various localities and with different classes of people and the use by cities working under different conditions and varying state laws has naturally suggested some changes in the units; but these are slight, and in fact, the changes recommended consist of only one or two minor additions to the units, and changes in the definitions in order to make their meaning more clear. In order, however, to answer such objections as have been raised, since the same objections will probably suggest themselves to others who have not yet expressed them to the committee; and in order to furnish the members with reasons and arguments, not only why they should themselves adopt the units and advocate their use, but by which they may reply to the critic upon whom they urge them, the committee thinks it desirable to discuss the objections raised to the definitions of the units. Finally, it will suggest that the committee be continued, with instructions to use its endeavors toward securing a more general adoption of the units.

One comment was with reference to the size of the cards on which the units were printed, the writer suggesting that these be made the size of an ordinary letter head, $8\frac{1}{2}$ by 11, in order to fit the standard letter file. The aim of placing them on these cards was largely to prevent the filing of the units in the letter file, but to make it convenient to keep the card in some place on the desk or table of the engineer, using it as a book mark or carrying it in the

vest pocket. The committee would be glad of an expression of opinion of the Society upon this point.

Of the two comments from engineers of New York cities, one writes that "in view of the fact that in many cities the cost of a pavement includes not only the pavement itself, but the base and the excavation, may I suggest the feasibility of the following:

"Pavement A is a standard unit which would include only the pavement or wearing surface with binder, if any is used.

"Pavement B would include the base and excavation, as well as the wearing surface. The cost of pavement B could be then compared with the combined cost of pavement A, plus its cost of base and its cost of excavation. It would seem that unless this was done, there will still be lacking a basis of comparison, and as the adoption of the units as printed would call for the engineer in cities where the base and excavation are included in the bid price per square yard to make earth work computation solely for the purpose of reporting his work, I am inclined to think this added burden would prevent many engineers reporting their work at all." In reply to this, the committee would say, if the engineers include excavation in the cost of paving it does not seem to be very important whether they *do* report their work at all, since the figures would be of little value or interest to any one except the few individual property owners of their own city who have to pay the costs of the pavement in question. As to including the cost of the foundation, the definitions of this committee provide for this by stating that in such case it should be described as "pavement and . . . inch concrete (or macadam) base." One of the chief aims of the paving units was to secure the separation of the cost of excavation from the cost of the pavement.

An engineer from Iowa reports that "it will be practically impossible to report all paving, curb, gutter and sidewalk improvements in Iowa entirely exclusive of grading, as the Iowa law provides that the cost of necessary excavation below grade is part of the unit price bid for the construction." We learn that the law referred to requires that "the construction of permanent parking, curb, paving, graveling, macadamizing or gutter, shall be done only after the bed therefor shall have been graded, so that such improve-

ment when fully completed will bring the street, highway, avenue or alley up to the established grade; provided that only so much of the cost of the removal of the earth and other material as lies between the sub-grade and the established grade shall be assessed to the abutting property." We can find nothing in this law which prevents the engineer from sub-dividing both the contract and the reported costs in accordance with our standard units; the law merely does not *require* him to make such separation. In this case, any excavation which originally extended above the finished grade of the pavement must be measured and calculated and if the excavation was in every case greater in depth than the thickness of the pavement, it would be easy to calculate the total amount of excavation. There will, however, be a very large amount of city work, especially repaving, in which there will be no excavation or an amount less than the thickness of the pavement to be laid, and the uncertainty of how much this excavation amounts to is the doubtful element in the figures reported. It does not seem to us at all probable that contractors figuring upon work in Iowa would take no account whatever of the amount of material to be excavated where this is a less depth than the thickness of the pavement to be constructed, and therefore, the excavation would be reflected in the price and should be taken into account by any engineer who wishes to be able to estimate upon the cost of future work.

With reference to curb, the sub-committee on curbs recommends that the item curb should be separated, as in the case of sidewalk and pavement, into the curb proper and the base and backing, which may be in some cases concrete and in others cinders or gravel or sand. There is no question but that this is correct and the only reason for not having made this separation before was that there are very few cities which separate these two items in their contracts or cost records and there, therefore, seemed little prospect of the adoption of such units. Now, however, that the units of the Society have obtained such general recognition, it would seem desirable to endeavor to secure this separation of units and we recommend that the unit curb be considered to include only the stone or concrete construction thereof, naming the average dimensions, and that there be the additional unit of foundation (which would include backing), giving the standard cross-sectional area of the

combined foundation and backing as shown on the standard plans and naming the material.

The matter of combined curb and gutter has presented some difficulties to the committee. It was originally the idea that this construction be reported separately as curb and as gutter. In view of several comments received, however, we would suggest the addition of a unit "combined curb and gutter," the measurement to be expressed in linear feet, giving the dimensions of both curb and gutter; as, for instance, 1,720 feet of combined concrete 6 by 12 curb and 6 by 18 gutter; the depth of curb being taken to the under side of the construction, and the width of gutter being measured from the face of the curb.

Concerning the sewer units, one member suggests that the depth of excavation be measured from the under side of the pavement down to the under side of the sewer. The principal reason why the committee cannot recommend the adoption of this is the practical one that almost all levels taken by the engineer are the elevation of the surface of the street; while the elevation of the sewer, which is almost invariably shown upon the profile and is probably the only one referred to in recording, is that of the sewer invert. If this is understood, there would seem to be no difficulty or doubt in the mind of the contractor or anyone else; since it will be understood that the excavation for the sewer will be carried to a depth below the invert line which will be a constant and equal to the thickness of the sewer, which also is a constant for any given cross section. While it is true that the excavation of the pavement at the top is a different matter from that of the ground under it, the units provide for a special cost item and special bid under the head of "replacing pavement," which unit and price is to include the removal and replacing, the contractor presumably charging for the former the amount which such removal would cost in addition to what it would cost were the pavement replaced with ordinary soil. Moreover, sewer construction should in general precede paving on any street, in which case there would be no pavement to remove.

One of the criticisms from New York state engineers was that the unit depth of manhole be considered as 1 foot rather than 6 feet. The reason for adopting 6 feet was as follows: Very few sewers are laid at a depth less than 6 feet, and it may therefore be as-

sumed that few manholes would have less depth than this. Moreover, owing to the difficulty of bringing in the walls of a manhole from a large and frequently oval bottom to the smaller and circular top, the cost of a manhole less than 6 feet deep would probably be fully as great as that of a 6-foot manhole. Again, the standard plans in different cities for the bottoms of manholes frequently introduce special construction extending for 1, 2 or even 3 feet above the sewer invert, and the cast-iron manhole top may be from 8 to 18 inches deep; in consequence of which $4\frac{1}{2}$ feet would seem to be the minimum depth from street surface to invert which would be certain to include all construction other than the mere masonry walls of the manhole.

There would seem to be, however, considerable force in the argument that the weight of the cast-iron manhole head should be itemized separately, but the committee does not at this time recommend this for the following reason: As stated, different cities have different designs for and methods of constructing the bottoms of manholes, which differences would, of course, affect the cost of these, and yet it is impracticable to explain such differences in the standard unit. Comparison of the standard 6-foot depth of manhole must therefore be recognized as being between designs which are different and therefore not directly comparable unless the plans for the manholes are at hand, but the cost per foot of additional depth will ordinarily cover mere brick or concrete walls of more or less uniform thickness. This does not mean that such comparison of manholes is of no use, however, for if a city should find that another city, on a line of sewers of the same size as its own, is building manholes at a less cost, it would naturally suggest a study of the design of manhole used by the other city to determine whether that of the city in question is unnecessarily expensive. The committee, however, is still open to argument on this point, and would be glad of an expression of opinion by engineers as to their preferences in the matter.

One suggestion indicates that the definition of the unit of sewer construction was not sufficiently explicit, in that it did not state that the measurement of sewer should be made along the invert or a line parallel thereto, and not in a horizontal line. This will be corrected in future publications of the units.

The sub-committee on Street Paving and Repair recommends that there be added to the paving units a provision for stating the length of maintenance, if any. Since maintenance periods are different in different cities, and contractors certainly should and in most cases probably do make a charge for the same, varying with the duration, this suggestion seems to be appropriate and will be adopted in the future.

The chairman of the committee has prepared amplified definitions of the units which have been advocated this year, and for the purpose indicated above these amplified definitions are appended to the report for the information and use of members of the society.

In its publicity work this year the committee spent about \$150. It would suggest that the committee be instructed to continue this work during the coming year, modifying the definitions of the units advocated as suggested above. Also that it urge the use of the sewerage terms, "inlet," "catchbasin," "storm sewer," "house sewer," "house sewage," "house connection," "inlet connection," as defined and adopted at last year's convention.

In the above report the decision of the members is requested on several points. And we recommend that next year's committee send to every member of the society a request for an expression of opinion on these points, and be authorized to adopt the decision of the majority in each case and include such in its publicity campaign. It is hoped that the committee will be appointed at once, so that the appeals for adoption of the units may be made at the first of the year, when, in a great many cities, new officials take charge.

STREET IMPROVEMENT UNITS.

Pavement is defined as "the wearing surface down to the base, if any." In an asphalt pavement this includes wearing and binder course. In a brick, stone or wood block pavement, the brick or block and sand or mortar cushion. In pavements like concrete or macadam, which have no base, the entire pavement to sub-grade is included.

A number of cities include the base with the top and may not wish to change, in which case this may be described as "pavement and base," but not as "pavement."

The reason for separating the two was that an increasing number of pavements on concrete base are being resurfaced on the old base, and this separation permits a comparison of cost of this repaving with the paving proper on a new base, and avoids confusion and uncertainty as to whether what is reported as "paving" does or does not include a new base. Also the thickness of base varies between cities and between different streets of the same city, and no true comparison can be made unless the thickness of base is known and allowed for, and this can be done most readily by considering the base separately.

Where the pavement is of a material such as asphalt, concrete, macadam, etc., which may be of different thicknesses, the thickness should be stated. Where there is a standard thickness, as a brick, wood block or stone block, this is not necessary.

Base.—Naming the material and amount of the base would seem to define this, especially if the proportioning of the concrete be given. Thus, a "6-inch, 1:3:6 concrete base" could hardly be made more definite without a long explanation. Some have preferred giving the cubic yards of concrete rather than the area and thickness, but there are two arguments in favor of the latter. To a certain extent the cost per cubic yard varies with the area covered, since this determines the frequency of moving the mixer or distance the concrete is wheeled from the mixer, and also the area of surface to be smoothed off. Given area in square yards and thickness, and a minute's calculation enables an engineer to reduce this to cubic yards. But (and this is the second argument) the figures are for the information of city officials and taxpayers, and if the cost per square yard of base is given, these can obtain the total cost by simple addition to the cost of pavement, while few would find it a simple matter to obtain such result if required to reduce cost per cubic yard (which means little to them) to cost per square yard.

Excavation is perhaps the most variable quantity occurring in most original paving work. It may vary from nothing to several feet, and should always be separated from pavement and base construction. Comparison of excavation costs is desirable, but is of less importance than the absolute elimination of their effect upon the cost of pavement and base.

Sidewalk.—That curb, gutter and sidewalk should not be included in work designated as "pavement" would seem to need little argument. The standard unit for sidewalk paving is used similarly to that for roadway paving. The square foot (or square yard, if preferred—the price will indicate which is used, even if it is not stated) is the unit to be used, giving average thickness and material. The unit does not include the base nor any excavation or embankment. The reasons are the same for the roadway. Including excavation or embankment would introduce such variables as to make any cost figure of no practical value, even for comparing paving in different contracts in the same city. Where there is a standard construction as to base in a given city, comparisons for that city of costs, including base, would be serviceable so long as the standard method was not changed. But such standard may be changed at any time, and, as it varies in different cities, comparisons between cities would be of little value unless the base be eliminated. If a city insists on lumping the two in one item, however, it should refer to this as "sidewalk and base." Example: 1,720 sq. ft. of 6-inch concrete sidewalk on 8-inch cinder base. The thickness of the sidewalk given is the average, if it is not uniform throughout. It would perhaps be well to specify whether the concrete is laid in one or two courses and the proportioning of the ingredients, as this can be stated briefly and adds to the definiteness of the statement, as: "1,720 sq. ft. of 6-inch, two-course, 1:2½:5 concrete sidewalk." But this is not considered as an essential to the standard unit.

Gutters.—For gutters also the standard unit is the square foot of stated thickness, naming the material. Present practice, where the roadway is paved with any material on a concrete or other base, is to continue the same wearing surface across the gutter to the curb, in which case the gutter is included as part of the pavement. Gutters as separate items are therefore, to a large extent, confined to macadam, gravel and dirt streets. They are generally of concrete, flat stone or cobble, the constructions of which are so different that the only practicable method of comparison appears to be to consider the whole construction under one item, which includes any base used, as well as the top surface, but does not include excavation or fill.

Curbs may be of concrete, without special backing or base, or of stone, preferably bedded on broken stone or concrete and with the same as backing. As in the case of gutters, therefore, it seems impracticable to consider the curb separate from the base and backing, and the whole is included as one item, with the linear foot, giving dimensions of curb, as the unit; this not to include excavation or drain tile, if any is used. Combined curb and gutter is given in linear feet, adding the width of gutter, thus: 1,720 feet of combined concrete 6 by 12 curb and 8 by 18 gutter.

SEWERAGE UNITS.

The standard units for sewer construction at present advocated are but four in number, and do not attempt to include all of the items of work encountered in such construction, but only the more important ones found in practically every sewer job. The units are "Constructing sewer;" "Branches;" "Manholes;" "Replacing pavement."

The first includes excavating the trench (except that rock is to be paid for extra under an additional item and that removing the street pavement is included under "replacing pavement"), furnishing pipe, brick or concrete, mortar and all other materials entering into the construction of the sewer barrel (that is, the main line of the sewer, not including branches, manholes, special foundations or other occasional features); constructing such sewer barrel and backfilling the trench (not including relaying the pavement). This would include practically if not quite all the work, except manholes, required on a long outfall line thru fields or a dirt road, where there were no branches to be inserted for house or storm water connections, no street pavement to be taken up and replaced, and no foundations to place, sheeting to be left in place, rock to be removed or anything but straight-away digging, pipe laying and backfilling.

The furnishing and laying of materials are directly comparable, one street with another and one city with another, if allowance be made for local costs of pipe and other materials, except possibly for minor variation in cost due to depth of trench and distance materials have to be teamed from yard or railroad siding. The depth of trench, however, may vary from 5 feet to 25 or even 50, and here

is one of the chief variables in sewer construction and prices. Eight-inch sewer pipe costs about 15 cents a foot; the excavating and backfilling for laying it may cost from 25 cents to \$2 or more a foot. To allow for this variation, the plan recommended (and the one followed by a very considerable number of engineers) is to classify the work by the depth of the trench, giving a separate classification for each 2 feet of depth. Example: 10-inch vitrified sewer, 950 feet, 8 to 10 feet deep; 630 feet, 10 to 12 feet deep; 720 feet, 12 to 14 feet deep, etc. In the first class would come the total length of trenches whose depth was more than 8 feet and less than 10 feet; in the second classification the total of all trenches between 10 feet and 12 feet depth, etc. To allow for contingencies, it is customary to make the first class "all less than 6 feet," or whatever depth appears from the profile, to the nearest even number to the minimum depth.

The depth is customarily measured from the ground surface to the lowest point of the inner surface—the "invert" or "flow line" of the sewer—and this is the definition provided for in the standard unit. Some have said that the logical depth would be to the lowest part of the outside of the sewer, since this measures the excavation; but this might give rise to questions and disputes or require elaborate explanations, as when extra excavation is required for cradles and foundations, sub-drains, or bell holes. These extra features are paid for in addition to the "constructing sewer" price, and the additional price can include the additional excavation required. The invert, however, is a fixed line, determined exactly by level and shown on the profile; for the latter reason it is the line to which contractors can most readily scale in taking depth from the profiles in preparing bids, and which the engineers can most readily use in making estimates. For pipe sewers, the additional inch would hardly be considered. For concrete or brick sewers it is simple to add the constant thickness of the standard invert depth.

Again there would seem to be some reason for measuring from the under side of the pavement rather than the surface, since pavement excavation is paid for additional. But the surface profiles are always given of the surface of the road, and it would be troublesome and give rise to disputes to have to allow for the thickness of the pavement, which would vary with each kind of pave-

ment and especially with macadam and telford which had worn down by varying amounts. The payment made for pavement excavation under the head "replacing pavement," therefore, is understood to be in addition to that for excavation included under the head of "constructing sewer."

The length of sewer included in the measurement paid for is the total over-all distance, measured along the invert, from the center of the manhole where a given size of sewer starts to the center of the manhole where it ends, or to the end of the sewer itself if it does not end in a manhole. Where one size changes to another by a reducer, each size is assumed to extend to the middle of the reducer, and an additional sum is paid for the reducing special; except that where a more or less elaborate reducing chamber is constructed to join large sewers and is paid for as a special construction, the measurements stop at the ends of such special construction. This practice might be criticized, in that part of this measurement include Y and T-branches and the manholes, and a payment is made for them as straight pipe and an additional payment as special construction. In defense it may be said that it has been the standard practice of many (the majority, we believe) of engineers for at least twenty-five years; that it is generally understood by contractors and leads to no confusion when it is specified that this will be the practice; that it avoids disputes as to the lengths to be deducted for each branch and manhole, and makes the calculations simpler and less liable to mistakes. The length should be the true length between the points mentioned, and not the horizontal distance; altho the difference between the two is not considerable, amounting to about 1 inch in 100 feet for a 4 per cent. grade.

As just stated, branches are paid for under two items, once as so much straight sewer, and again as "branches." A branch 2 feet long costs $2\frac{1}{2}$ times as much as 2 feet of straight pipe of the same size. The contractor therefore can simply charge for each branch $1\frac{1}{4}$ times the cost of 2 feet, or $2\frac{1}{2}$ times the cost of 1 foot of straight pipe of that size, plus an additional sum for capping the branch when this is done, which latter would probably be figured extra, whatever the method of measuring and paying.

Manholes are generally built with a special bottom provided with

a channel or channels, sidewalls of standard thickness, and a head and cover of iron; also with steps at stated vertical intervals. The depth has no effect upon the construction and cost of the bottom and top, but cost of side walls varies with the depth. Where a manhole is less than 6 feet total depth (measured from ground surface to invert) the construction is more difficult, and this fact would probably make a 4-foot or 5-foot manhole cost as much as a 6-foot one. The A. S. M. I. unit therefore takes the cost of a 6-foot manhole as a standard, receiving a bid on this entire, including bottom, top casting, side walls and steps; and an additional sum per vertical foot for additional depth of manhole, this consisting only of the wall and the steps therein. Thus, a 9-foot manhole would be recorded and bid upon as one standard depth manhole, plus 3 additional feet. This would seem to be much more rational and fairer to the contractor than to ask him to bid so much per manhole, regardless of the depth, requiring him to figure, estimate or guess what the average depth of manholes on any particular job will be.

"Replacing pavement" includes all the work of both removing and restoring all pavement over the trench which is additional to that which would be necessary in case of a dirt road; including the replacing with new ones of any blocks or other materials damaged in removing them. The unit of measurement is the square yard. The specifications sometimes specify what width of pavement strip will be paid for, in which case length of pavement replaced would be sufficiently definite for a given contract and given size of sewer. But the width will increase as the size of sewer increases above 15 or 18 inches, and the latter plan would therefore require a different bid per foot for each size of sewer greater than 15 or 18 inches, and would render it difficult to compare the prices on different pieces of work, therefore area seems the preferable unit. The kind of pavement is, of course, specified.

As to the numerous other features of sewer construction, as they are so irregular, differ so from job to job, and are not essential or peculiar to all sewer work, no effort has been made to establish standard units for them, for the present at least, altho the Society has adopted standard bidding blanks and standard specifications to cover them. Such are rock excavation, sheathing left in trench, foundations, sub-drains, catch-basins, flush-tanks, etc.

A. S. M. I. STANDARD UNITS FOR STREET PAVING.

If these units are used, a statement to that effect in a report or description, without further explanation, gives certainty of meaning to the figures.

Pavement.—The wearing surface down to the base, if any. Includes cushion or binder course, but not concrete, macadam, or other base. If base is included, describe as “pavement and . . . inch concrete or macadam base.” In the case of macadam or concrete pavement, the term includes all down to the earth foundation. *Unit, the square yard*, giving material and thickness. Ex.: 1,524 sq. yds. of 3-inch asphalt pavement.

Base.—The concrete, macadam, or other material placed under the pavement to distribute the load on the sub-grade. *Unit, the square yard*, naming thickness and material. Ex.: 1,524 sq. yds. of 6-inch concrete base.

Excavation; Embankment.—All material removed before laying base, curb or sidewalk; or all material added, up to base, curb or sidewalk. *Unit, the cubic yard*, naming material. Ex.: 600 cu. yds. of earth excavation.

Curb.—Complete construction of new curb, except excavation or embankment. **Resetting Curb.**—Same, except furnishing of curb stone. *Unit, linear foot*, stating (in inches) depth and mean width of curb and material. Ex.: 952 feet of 7 by 18 granite curb reset; 750 feet of 6 by 16 concrete curb.

Gutter.—Same as curb. *Unit, square foot*, stating thickness and material. Ex.: 1,428 sq. ft. of 6-inch concrete gutter.

Sidewalk.—The artificial wearing surface, not including excavation or embankment, nor base of cinders or other material, if any. *Unit, the square foot* (or square yard, if preferred), giving average thickness and material. Ex.: 1,720 sq. ft. of 6-inch concrete sidewalk.

Sidewalk Base.—Cinders or other material placed under sidewalk. *Unit, the square yard*, stating thickness and material. Ex.: 122 sq. yds. of gravel sidewalk base.

A. S. M. I. STANDARD UNITS FOR SEWER CONSTRUCTION.

If these units are used, a statement to that effect in a report or description, without further explanation, gives certainty of meaning to the figures.

Constructing Sewer.—Excavating trench (except rock and street pavement), furnishing material for and constructing or laying the sewer barrel (not including branches, manholes or other appurtenances, special foundations, etc.) and backfilling (not including relaying pavement). Excavation of rock, sheathing left in trench, and removal and replacing of pavement paid for extra. Depth of excavation is measured from street surface to invert of sewer, and classified by 2-foot intervals. *Unit, the linear foot* (measured along the invert line for the entire length of the sewer, including manholes and specials), naming size of bore and material of sewer, and depth. Ex.: 10-inch vitrified sewer, 950 feet 8 to 10-feet deep; 630 feet 10 to 12 feet deep.

Branches.—Y or T branches inserted in the sewer; the price paid to be additional to that paid for the sewer in which the branch is inserted.

Manhole.—The total structure, including bottom and top casting, steps, etc., additional excavation and backfilling. Standard to be taken as 6 feet deep, measured from the top of cover to sewer invert at center of manhole, and depths exceeding this to be given in additional feet depth. Price is in addition to that paid for sewer (measurement for which includes manholes, as stated above). *Unit, manhole of standard depth*, giving bottom diameters in feet; and feet of additional depth. Ex.: 7 manholes 3 by 4½, and 22 feet additional depth. (This means that the sum of the depths was 64 feet, and the average depth was 9 1/7 feet.)

Replacing Pavement.—Grading top of trench back-fill, putting in pavement foundation (if any), and laying wearing surface (replacing any material damaged in removing same). *Unit, square yard*, naming kind of pavement. Ex.: Removing and replacing 726 sq. yds. of brick pavement.

DISCUSSION.

MR. NORTON (by letter): The writer is most heartily in favor

of obtaining unit costs and values. Excellent work has been done by our Committee and it will be a pleasure to vote for its adoption.

However, no question is settled right until all phases have been discussed, and there are such phases which this Society must recognize and meet, especially in a more complete definition of units and explanation of uses to which the information tabulated may be put.

The matter may be briefed as follows:

A. Unit price bids as ordinarily submitted have little relation to either cost or value.

B. To obtain unit bid prices precludes lump sum bidding, which has some distinct merits as well as disadvantages.

C. Impossibility of making tabulations which will be fairly comparable without extended explanations.

D. Danger of mis-use of such tabulated information without knowledge of attendant conditions.

To illustrate the real lack of value of unit bid prices as having any relation to costs, the preceding two issues of a prominent engineering paper were taken at random and analysis made of all bids there reported where the item units for three lowest bidders were given.

Six sets of bids were received in five different cities, representing a great variety of work. These bids were tabulated under bidders A, B and C; bidder A being lowest on the extended totals for the work and C the highest. The total number of items studied was 247 and the extended totals of low bids about one and one-third million dollars. The random choice of bids and large amount of work involved are believed to make the results shown fairly representative.

The first point noted was that the low bidder, A, was higher on some items than B or C. In 39 per cent. of items A was tie or higher than the others. The per cent. which the highest item price was of the lowest was then taken, that is, if the low item bid was 20 cents and the high 30 cents, then 30 was listed as 150 per cent. of the low item price. This was carried out for each item and

then averaged for that job and also averaged for the six jobs. In the closest contract, the high items averaged over $1\frac{1}{2}$ times the low, and in one over 7 times the low. The average for the whole 247 items was high item over $2\frac{1}{2}$ times the low item price. Strangely enough, the extended totals for the highest bidders averaged less than 10 per cent. above that of the lowest bidder, that is, the average item variation was 253 per cent., while the actual difference between total high and low bids was but 109.8 per cent., or item variation was $2\frac{1}{3}$ times the variation in total cost.

This is not an exceptional but a general condition inherent to unit price bidding. What is the reason?

After more or less confidential conversation with various contractors, some explanations may be noted:

1. Probability of omission or reduction in quantities on some items and of increase on others over estimated quantities;
2. Hurried estimating in which no endeavor is made to ascertain costs on minor items;
3. Disinclination of certain bidders to give actual cost prices on specialties in their line of work, preferring to mix up such with other items that their actual figures may not be available to less experienced competitors.

A further large departure from true values may not appear in this tabulation, that of the common custom of bidding high on items to be first placed to obtain early and relatively large payments on partial estimates.

With these easily substantiated facts and figures before us, how can we pin much engineering faith to a tabulation of unit bid prices?

Three average reputable bidders will bid on totals within 10 per cent., but on items will vary ten times such amount—why are these items indicative of cost or value?

Lump sum bids have their advantages as well as disadvantages on work where extent and character can reasonably be foretold.

1. Knowledge of exact price in advance of work.

2. No incentive for acquisitive contractors or parsimonious engineers to change relative quantities to suit their own ends, where the unbalanced item price offers much inducement.

3. No disputes over classification of materials.

4. No disputes over computation of quantities. Such should be computed by both before beginning work.

5. No unit bid prices to demand undue payments on items early placed in work.

6. No unbalanced bids to make endless trouble in local assessment work.

7. Marked tendency to make quantity estimates much more accurately.

The impossibility of showing elements of legitimate costs in tabulated or comparative form needs little proof. The cost of a sewer may be tabulated under size, depth, manholes and other items, but the cost may vary several hundred per cent. within a thousand feet in one city, owing to soil, rock, water, traffic and many other items. A square yard of a standard pavement may be most easily considered a standard unit, but has your Committee made provision for showing whether or not the street has car tracks, or its width and traffic as affecting a five-year guarantee?

A square yard of average pavement will weigh .6 ton. If laid 1 mile or 4 miles from source of material-supply will make a difference of 3 miles in haul which, at 15 cents per ton mile in the city, would make a difference in actual cost of 27 cents per square yard. Can such be shown in a tabulation?

Other phases of costs were nicely illustrated in a recent bidding on a small sewer in deep, hard clay excavation. An unusually low bid was received. Afterward, second bidder said to the low one: "Charlie, I will be obliged to get a machine like yours, my machine can't compete in that stuff." "Well," said Charlie, "I had no other work for this machine for two weeks and this just fills in nicely, but had the job been near where the machine now is, instead of 4 miles away, I could have bid 5 per cent. lower."

Note here that the availability of suitable machinery made the

low price. Had it been absent or engaged the next bidder would have been low.

Also, note that location had a material bearing on cost.

A sister city has a most enviable record for its municipal asphalt construction and maintenance.

In answer to the question, the asphalt man said they were getting an average life of pavement of seventeen years. Buffalo is getting nearly twenty-three. Was this man ignorant of what he was getting for his money expended or is Buffalo asphalt worth 25 per cent. more? Who knows?

Undigested statistics in the hands of the inexperienced, the ignorant or the troublemaker may readily lead to confusion or worse.

The writer would again state that he favors the dissemination of all possible data as to costs in unit form, but would sincerely urge that much that is published should have the green light for caution displayed in its heading and with a foot note to "shake well before using."

Your Committee has sent out an advance report with a memorandum calling attention to some terrible examples in lump sum bidding. As the most horrid example seemed to apply so well to Buffalo, the coat was tried on and found to fit. However, it should be noted that Buffalo has given to members of this Society and the public the most complete analysis of the durability, cost of maintenance and consequent cost of providing a pavement over a long term of years. This would seem a more true method of arriving at actual cost and values. This Society should use its endeavors to arrive at a more definite unit of cost than bids permeated with the personal equation of the bidder and referring to items at times no more definite than the size of a lump of coal or the value of a yard of cloth—ribbon or broad-cloth.

MR. CHRIST: Were you considering any new units in the paving?

MR. FOLWELL: We had not considered any new units in the paving. If any of the members would like to recommend new units I think it is desirable that it be included in this questionnaire, as you might call it.

MR. CHRIST: I don't know of any in particular, but they only adopted four. I don't remember just exactly what they are. I should think the committee could look into that better than any one else.

SPECIFICATIONS FOR A GRAVEL ROAD.

ADOPTED OCTOBER 12, 1916.

These specifications will be modified from time to time to keep them fully up to date. Suggestions as to modifications or additions are solicited and should be sent to the Secretary, or to A. H. Blanchard, Columbia University, New York City, chairman of the sub-committee on Specifications for Broken Stone and Gravel Roads, and George W. Tillson, Boro Hall, Brooklyn, N. Y., chairman of the General Committee on Standard Specifications.

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1. *General Description.* The gravel road shall consist of three courses of mixtures of gravel, sand and clay, separately constructed, laid to conform to the required grades and cross-sections and constructed as hereinafter specified. The transverse slope of the finished surface of the gravel roadway shall be one (1) inch per foot.

2. *Subgrade.* The subgrade for the gravel roadway shall consist of the natural earth roadbed prepared and rolled until firm, hard and even, and shall conform to the specified cross-section. If sandy or other soil be encountered which will not compact readily under the roller, a small amount of clay, or other means satisfactory to the engineer, shall be used until a firm, even surface is obtained after rolling. Where the proposed grade allows the use of an old roadway for the subgrade, the roadway shall be shaped and rolled to the specified cross-section and elevations and depressions removed so as to form an even surface before the construction of the first course. The roller used shall be a ten (10) to fifteen (15) ton road roller.

3. *Shoulders.* After the roadbed has been graded, shoulders of firm earth or other suitable material eight (8) inches in depth after compaction, shall be constructed on each side of the roadbed at such distances apart as may be required to retain the width of gravel specified. No material which contains weeds, sod, roots or other perishable matter and which will not compact under the roller shall be placed in the shoulders. The shoulders shall extend

to the side ditches or gutters with the same transverse slope as required for the finished roadway surface and shall be thoroly rolled at the same time as the third or wearing course.

MATERIALS.

4. *Quality of Gravel.* All gravel shall be hard and tough. Gravel which contains over 10 per cent. of disintegrated stone shall not be used.

5. *Sizes.* Two mixtures of gravel, sand and clay shall be used hereinafter designated in these specifications as No. 1 product and No. 2 product.

No. 1 product shall consist of a mixture of gravel, sand and clay, with the proportions of the various sizes as follows: All to pass a one and one-half ($1\frac{1}{2}$) inch screen and to have at least 60 and not more than 75 per cent. retained on a one-quarter ($\frac{1}{4}$) inch screen; at least 25 and not more than 75 per cent. of the total coarse aggregate (material over one-quarter ($\frac{1}{4}$) inch in size) to be retained on a three-quarters ($\frac{3}{4}$) inch screen; at least 65 and not more than 85 per cent. of the total fine aggregate (material under one-quarter ($\frac{1}{4}$) inch in size) to be retained on a two hundred (200) mesh sieve.

No. 2 product shall consist of a mixture of gravel, sand and clay, with the proportions of the various sizes as follows: All to pass a two and one-half ($2\frac{1}{2}$) inch screen and to have at least 60 and not more than 75 per cent. retained on a one-quarter ($\frac{1}{4}$) inch screen; at least 25 and not more than 75 per cent. of the total coarse aggregate to be retained on a one (1) inch screen; at least 65 and not more than 85 per cent. of the total fine aggregate to be retained on a two hundred (200) mesh sieve.

6. *Test.* The mixture of gravel, sand and clay of the No. 1 product shall be subjected to a cementation test conducted by the engineer in accordance with the method recommended by the Special Committee on "Materials for Road Construction" of the American Society of Civil Engineers in January, 1916, and as described in the 1915 Proceedings, page 2738, except that the test shall be made on material which will pass a one-quarter ($\frac{1}{4}$) inch screen. Its co-efficient of cementation shall not be less than 50.

CONSTRUCTION.

7. *First Course.* After the subgrade or sub-base course shall have been prepared as specified, a course of No. 2 product shall be evenly spread so that it shall have, after rolling, the required thickness of three (3) inches. The depth of the No. 2 product loose shall be gaged by the use of strings between iron stakes, as directed. The spreading of the mixture of gravel, sand and clay must be from piles dumped on boards provided for the purpose or from piles dumped alongside the road. This course shall be thoroly rolled with a ten (10) to fifteen (15) ton road roller. The initial rolling shall begin at the sides of the road and continue towards the center and shall be kept up until there is no disturbance of the No. 2 product ahead of the roller. After the first course has been compacted water shall be sprinkled on the roadway surface just ahead of the roller in such quantity as shall prevent the sticking to the wheels of the roller of the fine material on the surface, and the combined watering and rolling shall be continued until the voids of the gravel become filled with fine particles and until the roadway surface conforms to the specified cross-section. After the completion of the rolling no teaming other than that necessary for bringing on the No. 2 product for the next course shall be allowed over the rolled surface. The surface of the first course shall be maintained in its finished condition until the second course shall have been spread. Should it be apparent after the rolling of the first course that the subgrade or shoulder material shall have become churned up into or mixed with the material of this course, whether by reason of the rolling or by hauling over the surface, or otherwise, the contractor shall at his own expense remove and replace such mixture of No. 2 product and subgrade or shoulder material with No. 2 product and shall roll the material to produce a uniform, firm and even first course as required.

8. *Second Course.* On the completed first course shall be spread, in the manner specified in the preceding paragraph, No. 2 product to form the second course. This mixture of gravel, sand and clay shall be evenly spread to such depth that it shall have, after rolling, the required thickness of three (3) inches. The second course shall be compacted, puddled with water and finished under the same provisions as prescribed for the first course. When

the rolling shall have been completed, the surface of the second course shall be firm, even and true to the lines, grades and cross-sections.

9. *Third Course.* On the completed second course shall be spread, in the manner above specified for the first course, No. 1 product to form the third course. This mixture of gravel, sand and clay shall be evenly spread to such a depth that it will have, after rolling, the required thickness of two (2) inches. The third course shall be compacted and puddled with water under the same provisions as prescribed for the first course. When the rolling shall have been completed, the surface of the third course shall be firm, even and true to the lines, grades and cross-sections. If necessary to satisfactorily bond the roadway surface, the third course shall then be evenly covered with a thin layer of sand or sand and clay and rolled.

PAYMENT.

10. *Measurement and Payment.* The quantity of gravel road to be paid for shall be the number of square yards, measured horizontally, satisfactorily completed in accordance with the specifications. The price stipulated shall include shaping and rolling of the subgrade, the furnishing of the different products of gravel, sand and clay, the placing, rolling and watering of the several courses, and all work and expenses incidental to the completion of the gravel road. (The quantity of shoulders shall be paid for under a separate item.)

SPECIFICATIONS FOR CREOSOTED WOOD BLOCK PAVING.

ADOPTED OCTOBER 13, 1916.

These specifications will be modified from time to time to keep them fully up to date. Suggestions as to modifications or additions are solicited and should be sent to the Secretary, or to Ellis R. Dutton, City Hall, Minneapolis, Minn., chairman of the sub-committee on Specifications for Creosoted Wood Block Paving, and George W. Tillson, Boro Hall, Brooklyn, New York, chairman of the General Committee on Standard Specifications.

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TIMBER

Kind. The wood from which the blocks are to be manufactured shall be Southern yellow pine, Douglas fir, Tamarack, Norway pine, hemlock or black gum. Only one kind of wood shall be used in any one contract.

Quality. The blocks must be sound and must be well manufactured, square butted, square edged, free from unsound, loose or hollow knots, knot-holes and other defects such as shakes, checks, etc., that would be detrimental to the blocks.

The number of annual rings in the one-inch which begins two inches from the pith of the block shall not be less than six, measured radially; provided, however, that blocks containing between five and six rings in this inch shall be accepted if they contain 33 1-3 per cent. or more summer wood. In case the block does not contain the pith, the one inch to be used shall begin one inch away from the ring which is nearest to the heart of the block. The blocks in each charge shall contain an average of at least 70 per cent. of heartwood. No one block shall be accepted that contains less than 50 per cent. of heartwood.

Size of Blocks. The blocks shall be from five to ten inches long, but should preferably average two times the depth; they shall be *

* The committee recommends blocks 4 inches in depth for very heavy traffic streets; blocks 3½ inches in depth for moderate traffic streets. For light traffic streets blocks 3 inches in depth may be used, but where 3-inch blocks are used, no block shall be longer than 8 inches.

inches in depth. They may be from 3 to 4 inches in width, but in any one city block all of them shall be of uniform width. A variation of 1-16 inch shall be allowed in the depth, and $\frac{1}{8}$ inch in the width of the blocks from that specified. In all cases the width shall be greater or less than the depth by at least $\frac{1}{4}$ inch.

PRESERVATIVE.

Kind. The preservative to be used may be either a coal-tar paving oil or a coal-tar distillate oil, as herein specified; or where refined water-gas tar is desired, the specification as below suggested may be used.

Coal-Tar Paving Oil. The oil shall be a coal-tar product of which at least 65 per cent. shall be a distillate of coal-gas tar or coke-oven tar, and the remainder shall be refined or filtered coal-gas tar or coke-oven tar. It shall comply with the following requirements:

1. It shall not contain more than 3 per cent. of water.
2. It shall not contain more than 3 per cent. of matter insoluble in benzol.
3. The specific gravity of the oil at 38 deg. C. shall not be less than 1.07 nor more than 1.12.

4. The distillates, based on water-free oil, shall be within the following limits:

Up to 210 deg. C. not more than 5 per cent.

Up to 235 deg. C. not more than 25 per cent.

The residue above 355 deg. C., if it exceeds 35 per cent., shall have a float test of not more than 80 sec. at 70 deg. C.

5. The specific gravity of the fraction between 235 deg. C. and 315 deg. C. shall not be less than 1.02 at 38 deg./15.5 deg. C.

The specific gravity of the fraction between 315 deg. C. and 355 deg. C. shall not be less than 1.02 at 38 deg./15.5 deg. C.

6. The oil shall not yield more than 10 per cent. coke residue.

Coal-Tar-Distillate Oil. The oil shall be a distillate of coal-gas

tar or coke-oven tar, and shall comply with the following requirements:

1. It shall not contain more than 3 per cent. of water.
2. It shall not contain more than 0.5 per cent. of matter insoluble in benzol.
3. The specific gravity of the oil at 38 deg. C., shall be not less than 1.06.

4. The distillates, based on water-free oil, shall be within the following limits:

Up to 210 deg. C. not more than 5 per cent.

Up to 235 deg. C. not more than 15 per cent.

The residue above 355 deg. C., if it exceeds 10 per cent., shall have a float test of not more than 50 sec. at 70 deg. C.

5. The specific gravity of the fraction between 235 deg. C. and 315 deg. C. shall be not less than 1.02 at 38 deg./15.5 deg. C.

The specific gravity of the fraction between 315 deg. C. and 355 deg. C. shall be not less than 1.09 at 38 deg./15.5 deg. C.

6. The oil shall yield not more than 2 per cent. of coke residue.

In view of the fact that some cities are using a water-gas tar, your committee deems it advisable to suggest a specification for their guidance. This specification is the one submitted and agreed to by Mr. C. N. Forrest, chemist of the Barber Asphalt Paving Company, and Mr. W. H. Fulweiler, chemist of the United Gas Improvement Company, as follows:

The preservative shall be refined water-gas tar, and shall comply with the following requirements:

1. The specific gravity shall be not less than 1.12 nor more than 1.14 at 38 deg. C., referred to water at the same temperature.
2. Not more than 2.0 per cent. shall be insoluble by hot extraction with benzol and chloroform.
3. On distillation which shall be made as hereinafter described,

the distillate, based on water-free oil, shall be within the following limits:

Up to 210 deg. C., not more than 5.0 per cent.

Up to 235 deg. C., not more than 15.0 per cent.

Up to 315 deg. C., not more than 40.0 per cent.

Up to 355 deg. C., not less than 25.0 per cent.

4. The specific gravity of the total distillate below 355 deg. C., shall not be less than 1.00 at 38 deg. C., referred to water at the same temperature.

5. The oil shall not contain more than 2.0 per cent. water and due allowance shall be made for all water and insoluble foreign matter it may contain by injecting a corresponding additional quantity into the blocks.

TREATMENT.

The timber may be either air-seasoned or green, but should preferably be treated within three months from the time it is sawed. Green timber and seasoned timber shall not, however, be treated together in the same charge. The blocks shall be treated in an air-tight cylinder with the preservative heretofore specified. In all cases, whether thoroly air-seasoned or green, they shall first be subjected to live steam at a temperature between 220 deg. and 240 deg. F., for not less than 2 hours nor more than 4 hours, after which they shall be subjected to a vacuum of not less than 22 inches, held for at least one hour. While the vacuum is still on, the preservative oil, heated to a temperature of between 180 deg. and 220 deg. F., shall be run in until the cylinder is completely filled, care being taken that no air is admitted. Pressure shall then be gradually applied not to exceed 50 lbs. at the end of the first hour, and then maintained at not less than 100 lbs. nor more than 150 lbs. until the wood has absorbed the required amount of oil.**

After this, a supplemental vacuum shall be applied, in which the maximum intensity reached shall be at least 20 inches, and shall

** This treatment is recommended for yellow pine only. It is probably also suited to Norway pine, hemlock, black gum and tamarack, but not to Douglas fir. Further recommendations on the treatment of these species are reserved for the future.

continue for a period of not less than 30 minutes. If desired, this vacuum may be either preceded or followed by a short steaming period.

In any charge the blocks shall contain at least 16 pounds of water-free oil per cubic foot of wood at the completion of the treatment. The blocks after treatment shall show satisfactory penetration of the preservative, and in all cases the preservative must be diffused thruout the sapwood. To determine this, at least twenty-five blocks shall be selected from various parts of each charge, and sawn in half at right angles to the fibers, thru the center, and if more than one of these blocks show untreated sapwood, the charge shall be retreated. After re-treating, the charge shall again be subjected to a similar inspection.

The surface of the blocks after treatment shall be free from deposit of objectionable substances, and all blocks that have been materially warped, checked or otherwise injured in the process of treatment shall be rejected.

Handling Blocks After Treatment. Blocks shall preferably be laid in the street as soon as possible after being treated. If they cannot be laid within two days, provision shall be made to prevent them from drying out by stacking in close piles and covering them, and if possible, sprinkling them thoroly at intervals. The blocks shall be well sprinkled, under direction of the purchaser, about two days before being laid.

Inspection. All material herein specified and processes used in the manufacture of the blocks therefor, shall be subject to inspection, acceptance or rejection at the plant of the manufacturer, which shall be equipped with all the necessary gages, appliances and facilities to enable the inspector to satisfy himself that the requirements of the specifications are fulfilled.

The purchaser shall have the further right to inspect the blocks after delivery upon the street, for the purpose of rejecting any blocks that do not meet these specifications, except that the plant inspection shall be final with respect to the oil and treatment.

FOUNDATION.

The foundation for the pavement shall be of concrete made in

accordance with the specifications for concrete paving foundations and shall be * inches in thickness. At no place shall the surface of the finished concrete vary more than $\frac{1}{2}$ inch from the given grade.

CUSHION.

A—Bituminous. Over the concrete foundation laid as specified above shall be spread a layer of cement mortar composed of one part portland cement to two parts of sand. This mortar shall be of such consistency that it may be easily spread, and must be applied to the surface of the concrete not more than 45 minutes after the placing of the concrete foundation. This mortar must be struck by templates to a surface parallel to the grade and contour of the finished pavement in such a manner that when the blocks are set the surface of the pavement shall conform accurately to the established grade. After this mortar coating is thoroly set and hardened, it shall be painted with a coal tar pitch as specified under bituminous filler, or other suitable waterproofing paint. The paint coat must be applied as thinly and as smoothly as possible, and at no place shall it be over $\frac{1}{8}$ inch in depth. The blocks shall be laid as specified below, directly on this paint coat, within at least 30 minutes after it has been applied.

B—Mortar Bed. The concrete foundation prepared as specified above shall be cleaned and swept, and shall be thoroly dampened immediately in advance of the spreading of the cushion course. Upon the surface of the foundation thus prepared shall be spread a layer of mortar not exceeding $\frac{1}{2}$ inch in thickness and made of one part portland cement of the character specified for use in the foundation, and three parts of sand. Only sufficient water shall be added to this mixture to insure a proper setting of the cement, the intention being to produce a granular mixture which may be raked or struck by templates to the desired grade. The mortar shall be thoroly mixed and shall be spread in place upon the foundation by means of templates immediately in advance of the laying of the blocks, to such a thickness that when the blocks are set and properly bedded in the mortar, their tops shall conform accurately to the finished grade of the roadway.

* Note: The committee recommends that the concrete base be at least 5 inches in thickness, and under heavy traffic 8 to 9 inches is recommended.

C—Sand. Upon the concrete foundation shall be spread a cushion of sand 1 inch in thickness. The sand cushion shall be struck by templates to a surface parallel to the grade and contour of the finished pavement in such a manner that when the blocks are set and thoroly bedded in the sand, the tops shall conform accurately to the finished grade of the pavement. The sand used in this cushion shall all pass thru the $\frac{1}{4}$ -inch screen and must contain between 10 and 25 per cent. of loam or clay.

LAYING THE BLOCKS.

Upon the bed thus prepared the blocks shall be carefully set with the fiber of the wood vertical, in straight parallel courses, leaving a space next to the curb 1 inch in width for the expansion joint.

They shall be placed closely together on the prepared cushion, and no joint shall be more than $\frac{1}{8}$ inch in width. Nothing but whole blocks shall be used except in starting a course, or in such other cases as the purchaser may direct; and in no case shall the lap joint be less than 2 inches. Closures shall be carefully cut and trimmed by experienced men. The portions of the block used for the closures must be free from checks or other fractures and the cut end must have a surface perpendicular to the top of the block and cut to the proper angle so as to give a close, tight joint. The angle of the course with the curb shall be determined by the purchaser.

After the blocks are placed, they shall be rolled parallel and diagonal to the curb by a tandem roller weighing between four and seven tons, until the surface becomes smooth and is brought truly to the grade and contour of the finished pavement. In case of a mortar bed, the rolling shall be completed before the mortar bed has set. All mortar that has set before the blocks are in place and rolled shall be discarded and replaced by fresh mortar.

FILLER.

A—Bituminous. After the rolling is completed, the joints between the blocks shall be filled with either a pitch or asphalt filler as specified hereafter. The filler shall be brought to the proper temperature and shall be poured into the joints, and any filler on

the surface of the pavement must be spread as thinly as possible by means of squeegees. The receptacle in which the filler is heated shall be equipped with suitable thermometers.

After the joints are filled as prescribed, the surface shall be completely covered by a thin coat of clean, coarse, dry sand, and a similar coating of sand shall be spread over the pavement, if required by the engineer, before the acceptance of the pavement.

a—Pitch Filler. The filler shall be a straight-run residue obtained from the distillation of coal tar, and shall comply with the following requirements:

1. The melting point shall be not lower than 140 deg. F. nor higher than 150 deg. F.
2. It shall contain between 22 per cent. and 37 per cent. of free carbon insoluble in hot chloroform and benzol.
3. Its specific gravity at 77 deg. F. shall not be less than 1.24 nor more than 1.32.
4. The specific gravity of the distillate up to 355 deg. C. shall not be less than 1.07 at 38 deg. C., compared with water at 15.5 deg. C.

The pitch shall not be heated to a temperature exceeding 325 deg. F., and shall be poured at a temperature between 250 deg. F. and 300 deg. F.

b—Asphalt Filler. The filler shall be an asphalt cement and shall comply with the following requirements.

1. It shall contain at least 98.0 per cent. of bitumen soluble in carbon di-sulphide.

2. It shall have a penetration within the following limits:

When tested at 32 deg. F. for 1 minute under 200 grams, 10 to 20.

When tested at 77 deg. F. for 5 seconds under 100 grams, 30 to 50.

When tested at 115 deg. F. for 5 seconds under 50 grams, 150 to 300.

3. It shall show a ductility of at least 30 centimeters when tested at 77 deg. F.

4. When 50 grams are heated in an open tin to a temperature of 325 deg. F. for 5 hours, the loss shall not exceed 1 per cent., and the penetration at 77 deg. F. of the residue left after such heating must not be less than two-thirds (2-3) of the penetration of the original asphalt cement before such heating when tested at 77 deg. F.

*B—Sand.** After the rolling is completed, the joints between the blocks shall be filled by sweeping dry, clean sand into them, after which the surface shall be covered to a depth of about $\frac{1}{2}$ inch with fine sand. This sand is to be left upon the pavement for such a time as may be directed by the city, after which it shall be swept up and taken away by the contractor.

When the blocks are laid on streets having grades of 3 per cent. or over, it is desirable that the blocks be spaced by laying creosoted wood lath of about 5-16 inch thick between courses. The space above the lath shall then be filled with heated crushed stone (containing no dust) and bituminous filler as specified above. The bituminous filler shall first be poured into the bottom of the joint, care being taken to get none on the surface of the pavement. The crushed stone shall then be swept into the joint, and the space around the stone filled with the bituminous filler to the top of the joint. It is essential in open joint pavement to drive the blocks together every four rows to prevent tipping of the individual blocks.

METHODS OF SAMPLING AND TESTING PRESERVATIVE AND FILLERS

Sampling. Continuous Drip Sample.

Wherever the oil is being loaded or discharged by means of a pump the following method shall be used:

The pipe line thru which the material is being pumped shall be tapped on the discharge side of the pump, preferably in a rising

* Sand filler and sand cushion have caused many failures, and where used, special care should be exercised.

section of the pipe line. The sample shall be taken by means of a $\frac{1}{2}$ -inch pipe extending half way to the center of the main pipe, and the inlet of the $\frac{1}{2}$ -inch pipe shall be turned to face the flow of the liquid. This pipe shall discharge into a barrel or drum of 50 to 100 gallons capacity, and the plug cock regulated so as to secure a continuous uniform stream during the entire pumping of the shipment. The barrel, or preferably the iron drum, should be provided with a small steam coil, sufficient to keep the contents thoroly liquid. The temperature shall not exceed 120 deg. F. The contents of the barrel or drum shall be very thoroly agitated and small samples for testing taken immediately. The amount of the drip sample collected shall be not less than 1 gallon to 1,000 gallons of material handled, excepting in the case of large boat shipments, where a maximum of 100 gallons will suffice.

Storage Tank Samples.

In sampling from storage it is necessary to secure samples from different levels, and where possible this may be done by means of small outlet cocks at regular intervals from the top to the bottom of the storage tank. In such cases, about 1 gallon of tar or oil shall be drawn from each outlet cock and thoroly mixed and a portion taken for testing. The stream from each cock shall always be allowed to flow for sufficient length of time to empty the outlet pipe and nipple before commencing to collect the sample.

When tanks have no outlet cocks a vessel having a string attached to the cork may be lowered to measured depth representing a number of the different levels in the tank and the cork removed when the vessel has reached the proper level. These samples shall be combined for an average as above.

TESTING.

Distillation Test. Apparatus for Distillation Test.

(a) *Retorts.* This shall be a tabulated Jena glass retort of the usual form with a capacity of 250 to 290 c.c. The capacity shall be measured by placing the retort with the bottom of the bulb and the end of the off-take in the same horizontal plane, and pouring water into the bulb thru the tubulature until it overflows the off-

take. The amount remaining in the bulb shall be considered its capacity. (Fig. 1.)

(b) *Condenser Tube.* Any suitable form of glass tubing may be used; a convenient one is shown in Fig. 1.

(c) *Shield.* An asbestos shield as shown in Fig. 2, shall be used to protect the retort from air currents and to prevent radiation. This may be covered with galvanized iron, as such an arrangement is more convenient and more permanent.

(d) *Receivers.* Erlenmeyer flasks of 50 to 100 c.c. capacity are most convenient form.

(e) *Thermometers.* The thermometer shall be of glass, well annealed, and shall undergo no serious change at the zero point when heated up to 400 deg. C. The space above the mercury column shall be filled with gas, either carbon dioxide or nitrogen, and the thermometer shall have an expansion chamber at the top.

The scale shall read from 0 to 400 deg. C., in graduations of 1 deg. C., which shall be etched on the stem.

The tip of the thermometer shall carry a ring for the purpose of attaching tags. The thermometer shall have the following dimensions:

Total length, 375 mm.; tolerance, 10 mm.

Bulb length, 14 mm.; tolerance, 1 mm.

Distance from zero mark to bottom of bulb, 30 mm.; tolerance, 4 mm.

Scale length from zero mark to 400 deg. C., 295 mm.; tolerance, 5 mm.

Diameter of stem, 7 mm.; tolerance, 1 mm.

Diameter of bulb, 6 mm.; tolerance, 1 mm.

When standardized the accuracy of such standardization should be as follows:

Up to 200 deg. C.	.....to the nearest 0.5 deg. C.
200 to 300 deg. C.	.....to the nearest 1.0 deg. C.
300 to 360 deg. C.	.....to the nearest 1.5 deg. C.

Assembling for Distillation Test.

The retort shall be supported on a tripod or rings over two sheets of 20-mesh gauze, 6 inches square. It shall be connected to the condenser tube by a tight cork joint. The thermometer shall be inserted thru a cork in the tubulate with the bottom of the bulb $\frac{1}{2}$ inch from the surface of the oil in the retort. The exact location of the thermometer bulb shall be determined by placing a central rule graduated in divisions not exceeding $\frac{1}{16}$ inch back of the retort when the latter is in position for the test, and sighting the level of the liquid and the point for the bottom of the thermometer bulb. The distance from the bulb of the thermometer to the outlet end of the condenser tube shall be not more than 24 nor less than 20 inches. The burner should be protected from draughts by a suitable shield or chimney. (Fig. 1.)

Distillation Test.

Exactly 100 g. of oil shall be weighed into the retort, the apparatus assembled and heat applied. The distillation shall be conducted at the rate of at least one drop and not more than two drops per second, and the distillate collected in weighted receivers. The condenser tube shall be warmed whenever necessary to prevent accumulation of solid distillates. Fractions shall be collected at the following points: Up to 210 deg. C.; up to 235 deg. C.; 235 to 315 deg. C.; 315 to 355 deg. C. The receivers shall be changed as the mercury passes the dividing temperature for each fraction. The last receiver shall be removed at 355 deg. C., and drainage from the condenser, etc., shall not be considered as part of the fraction. For weighing the receivers and fractions, a balance accurate to at least 0.05 g. shall be used. During the progress of the distillation the thermometer shall remain in its original position. No correction shall be made for the emergent stem of the thermometer.

When any measurable amount of water is present in the distillate it shall be separated as nearly as possible and reported separately, all results being calculated on a basis of dry oil. When more than 2 per cent. of water is present, water-free oil shall be obtained by separately distilling a larger quantity of oil, returning to the oil any oil carried over with the water, and using dried oil

for the final distillation. A copper tar still is a convenient means of obtaining water-free oil.

Specific Gravity Test. Apparatus for Specific Gravity Test.

(a) *Hydrometer.* The hydrometer shall be of the form and dimensions shown in Fig. 3.

(b) *Cylinder.* The cylinder shall be of the form and dimensions shown in Fig. 4.

Specific Gravity Test.

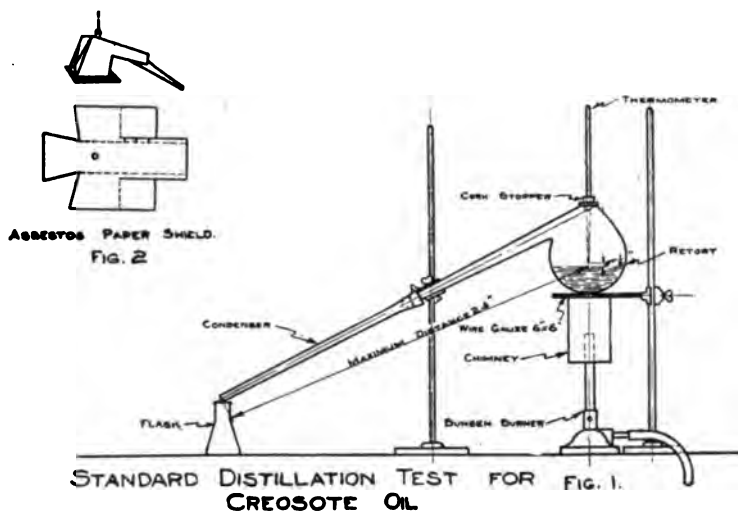
A standardized hydrometer (Fig. 3) shall be used. A set of two ranges, 1.00 to 1.08 and 1.07 to 1.15 will suffice. The reading should preferably be taken at 38 deg. C. (100 deg. F.), because at this temperature almost all oils are completely fluid.

Before taking the specific gravity the oil in the cylinder should be stirred thoroly with a glass rod, and this rod when withdrawn from the liquid should show no solid particles at the instant of withdrawal. Care should be taken that the hydrometer does not touch the sides or bottom of the cylinder when the reading is taken, and that the oil surface is free from froth and bubbles. If the specific gravity is determined at a higher temperature than desired, correction should be made by adding 0.0008 to the reading for each degree Centigrade excess of temperature.

Coke Test.

In making the coke determination, hard glass bulbs similar to the one shown in Fig. 5, are to be used. The test is to be carried out as follows:

Warm the bulb slightly to drive off all moisture, cool in a dessicator and weigh. Again heat the bulb by placing it momentarily in an open Bunsen flame and place the tubular underneath the surface of the oil to be tested and allow the bulb to cool until sufficient oil is sucked in to fill the bulb about two-thirds full. Any globules of oil sticking to the inside of the tubular should be drawn into the bulb by shaking or expelled by slightly heating it, and the outer surface should be carefully wiped off and the bulb re-weighed.

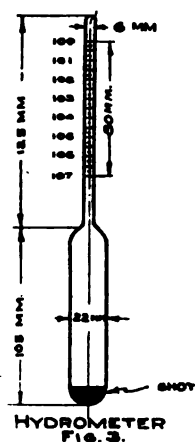


This procedure will give about one gram of oil. Cut a strip of thin asbestos paper about $\frac{1}{4}$ inch wide and about 1 inch long, place it around the neck of the bulb and catch the two free ends close up to the neck with a pair of crucible tongs. The oil should then be distilled off as in making an ordinary oil distillation, starting with a very low flame and conducting the distillation as fast as can be maintained without spurting. When oil ceases to come over, the heat should be increased until the highest temperature of the Bunsen flame is attained, the whole bulb being heated red hot until evolution of gas ceases and any carbon sticking to the outside of the tubular is completely burned off. The bulb should then be cooled in a dessicator and weighed, and the percentage of coke residue calculated to water free oil.

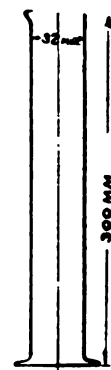
Float Test.

Method—The float apparatus consists of two parts, and aluminum float or saucer (Fig. 6-A) and a conical brass collar (Fig. 6-B). The two parts are made separately, so that one float may be used with a number of brass collars.

In making the test, the brass collar is placed with the small end down on the brass plate, which has been previously amalgamated with mercury by first rubbing it with a dilute solution of mercuric



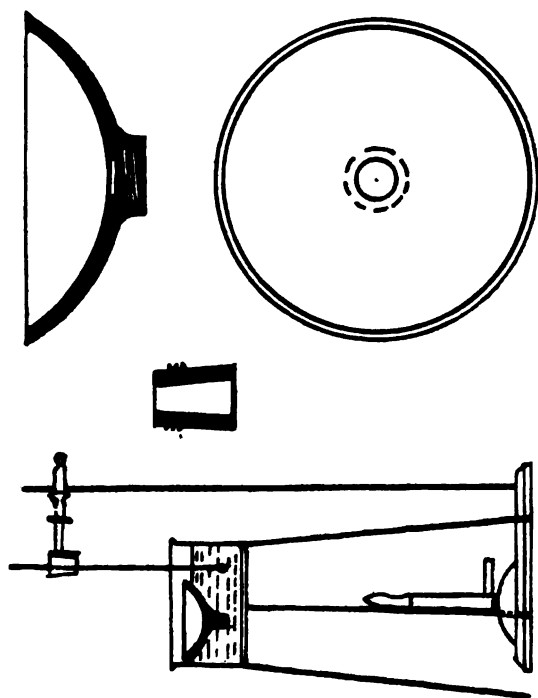
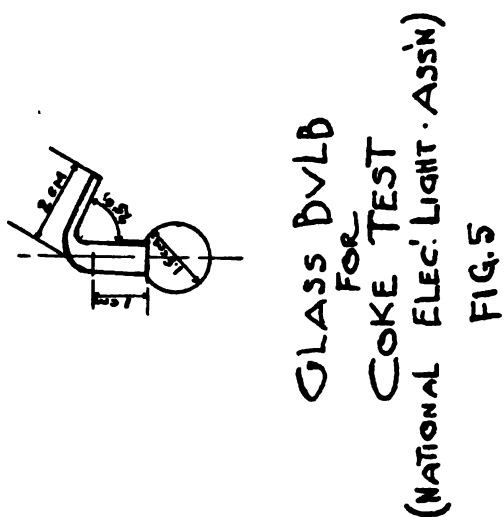
HYDROMETER
FIG. 3.



CYLINDER
FIG. 4.

chloride or nitrate and then with mercury. A small quantity of the material to be tested is heated in the metal spoon until quite fluid, with care that it suffers no appreciable loss by volatilization and that it is kept free from air bubbles. It is then poured into the collar in a thin stream until slightly more than level with the top. The surplus may be removed after the material has cooled to room temperature, by means of a spatula or steel knife which has been slightly heated. The collar and plate are then placed in one of the tin cups containing ice water maintained at 5 deg. C., and left in this bath for at least 15 minutes. Meanwhile, the other cup is filled about three-fourths full of water and placed on the tripod, and the water is heated to any desired temperature at which the test is to be made. This temperature should be accurately maintained and should at no time thruout the entire test be allowed to vary more than one-half a degree Centigrade from the temperature selected. After the material to be tested has been kept in the ice water for at least fifteen minutes, the collar with its contents is removed from the plate and screwed into the aluminum float, which is then immediately floated in the warmed bath. As the plug of bituminous material becomes warm and fluid, it is gradually forced upward and out of the collar until water gains entrance to the saucer and causes it to sink.

The time in seconds between placing the apparatus on the water and when the water breaks thru the bitumen is determined by



APPARATUS FOR FLOAT TEST
FIG. 6

means of a stop watch and is taken as a measure of the consistency of the material under examination.

Volatilization Test.

Twenty grams of the sample shall be placed in a weighed tin box $2\frac{1}{4}$ inches in diameter and $\frac{3}{4}$ of an inch (two ounces Gill style can, obtainable from the American Can Company) and heated five (5) hours at 325 deg. F. The heating shall be done in a ventilated oven which shall have reached the temperature specified before the introduction of the samples and which is maintained within two (2) deg. of that temperature thruout the test. The tin can should be insulated by a sheet of asbestos or other material from direct metallic contact with the sides or walls of the oven. The bulb of the thermometer should be immersed in a control bath immediately alongside of the sample being tested, the container and the method of insulation being the same in both cases. At the end of the five hours the sample is removed from the oven, cooled and weighed, the loss in weight being the loss due to heating at 325 deg. F. for five hours.

Melting Point Test.

The sample of pitch upon which the melting point is to be determined shall be molded into a one-half ($\frac{1}{2}$) inch cube and test conducted as described below.

The mold, which should be of brass, should have its sides either amalgamated or coated with French chalk so as to prevent the pitch from sticking to it. The sample of pitch shall be melting at a temperature of not exceeding 275 deg. F., or at a temperature sufficient to render it so fluid as to pour readily. The mold is then placed on an amalgamated brass plate and the molten pitch poured into it so that it is more than level full. After the pitch is cool the excess shall be cut off level by means of a hot spatulate. A No. 12 iron wire (B. & S. gage) about 8 inches long shall be filed to a point at one end. This end, for a distance of about $\frac{3}{4}$ inch, shall be bent at right angles to the rest of the wire. The half-inch cube of pitch is then inserted on the end of this short arm of the wire, the point of the wire passing thru the center of one of the faces of the cube so that the cube will hang with one of its edges

down. The iron wire containing the cube is then suspended in a beaker of water so that the edge of the cube is within 1 inch of the bottom of the beaker. A thermometer is then hung with its bulb on a level with the cube and less than one-half ($\frac{1}{2}$) inch from it. About 400 C. C. of water at 60 deg. F. should be placed in the beaker and the cube hung in it for at least five minutes, after which the water shall be heated by means of a burner so as to raise the temperature of the water at the rate of 5 deg. C. (9 deg. F.) each minute. The temperature recorded by the thermometer at the instant the pitch touches the bottom of the beaker is considered its melting point.

Determination of Material Insoluble in Benzole or Free Carbon.

Two grams of the oil or pitch are weighed out into a 50 c.c. Erlenmeyer flask and covered with about 20 c.c. of chemically pure benzole. The flask and contents are then carefully heated until the pitch or oil is melted into solution in the benzole. This heating should be for at least fifteen minutes. After which the contents of the flask shall be washed with as little benzole as possible onto a previously weighed 11 cm. filter paper (S & S 575 hardened). The material on the filter paper is then washed with benzole until the filtrate is a light straw color. The filter paper is then placed in the receptacle of any suitable extractor in which the hot vapors come into contact with the material being extracted (Wylie and others of same type are satisfactory). Benzole is placed in the extractor, which is run until the extract from the filter paper is colorless. The paper is then removed, dried and weighed, the increase in weight being considered as free carbon or matter insoluble in benzole.

If the extraction calls for benzole and chloroform, the same method is used as above described, excepting that chloroform is placed in the extractor in place of benzole and the final extraction continued with this solution until this filtrate is colorless.

Penetration Test.

Penetrations shall be taken by means of a penetrometer, which shall be so constructed as to correctly register, in one-hundredths of a centimeter the depth to which a Robert's Sharps No. 2 needle

will penetrate the sample under examination under a given load without appreciable retarding friction for a given time period.

Penetration at 32 deg. F.—For penetration test at 32 deg. F. the time period shall be one (1) minute and the total weight operating on the needle shall be two hundred (200) grams.

Penetration at 77 deg. F.—For penetrations at 77 deg. F. the time period shall be five (5) seconds and the total weight operating on the needle shall be one hundred (100) grams.

Penetration at 115 deg. F.—For penetration at 115 deg. F. the time period shall be five (5) seconds and the total weight operating on the needle shall be fifty (50) grams.

The sample to be tested shall be contained in a flat bottom cylindrical dish about $2 \frac{3}{16}$ inches in diameter and of a sufficient depth to insure a penetration of the sample without the needle touching the bottom of the receptacle.

The water bath shall be maintained at a temperature not varying more than .2 deg. F. from 77 deg. F. The volume of the water shall not be less than ten (10) litres and the sample shall be immersed to a depth of not less than four (4) inches and shall be supported on a perforated shelf not less than two (2) inches from the bottom of the bath.

The transfer dish for container shall be a small dish or tray of such capacity as will insure complete immersion of the container during the test. It shall be provided with some means which will insure a firm bearing and prevent rocking of the container.

Preparation of Sample—The sample shall be completely melted at the lowest possible temperature and stirred thoroly until it is homogeneous and free from air bubbles. It shall then be poured into the sample container to a depth of not less than $\frac{5}{8}$ inch. The sample shall be protected from dust and allowed to cool in an atmosphere not lower than 18 deg. C. (65 deg. F.) for one hour. It shall then be placed in the water bath along with the transfer dish and allowed to remain one hour.

Testing—In making the test the sample shall be placed in the transfer dish filled with water from the water-bath of sufficient

depth to completely cover the container. The transfer dish containing the sample shall then be placed upon the stand of the penetration machine. The needle, loaded with specified weight, shall be adjusted to make contact with the surface of the sample. This may be accomplished by making contact of the actual needle point with its image reflected by the surface of the sample from a properly placed source of light. Either the reading of the dial shall then be noted or the needle brought to zero. The needle is then released for the specified period of time, after which the penetration machine is adjusted to measure the distance penetrated.

The average of from three (3) to five (5) tests which must not differ more than five (5) points (five-hundredths—0.05—of a centimeter) between maximum and minimum shall be taken as the penetration of the sample, the needle being wiped off with a dry cloth after every determination.

Ductility Test.

Preparation of Briquette—The molding of the briquette may be done as follows:

The mold should be placed upon an amalgamated brass plate. To prevent the asphalt from adhering to the plate and the inner side of the two removable pieces of the mold, they should be well amalgamated. The different pieces of the mold should be held together in a clamp or by means of an India rubber band. The material to be tested is poured into the mold while in a molten state, a slight excess being added to allow for shrinkage on cooling. After the briquette is nearly cool, it is smoothed off level by means of a heated palette knife. When cooled, the clamp is taken off and the two side pieces removed, leaving the briquette of asphalt firmly attached to the two ends of the mold, which thus serves as clips.

After the briquette has been immersed in water and maintained at a temperature of 77 deg. F. for thirty (30) minutes it shall then be placed in any suitable ductility machine and the two ends pulled apart at the rate of five (5) centimeters per minute. This test must be done with the briquette under water and maintained at a temperature of 77 deg. F. until the entire operation is completed. Any piece of dirt or extraneous matter in the briquette may cause

a breaking of the fine thread before the true maximum ductility of the material under examination has been reached. Great care should be observed, therefore, to avoid the presence of such foreign matter in the bitumen when it is poured into the mold. The average of at least two tests shall be recorded as the ductility of the sample under examination. These tests must not differ more than twenty (20) per cent. from their average.

BUSINESS PROCEEDINGS
OF THE
TWENTY-THIRD ANNUAL CONVENTION OF THE
AMERICAN SOCIETY OF MUNICIPAL
IMPROVEMENTS.

Held at the Robert Treat Hotel, Newark, New Jersey,
October 10, 11, 12, 13, 1916.

TUESDAY, OCTOBER 12, 1915.

MORNING SESSION.

The convention was called to order by President Macallum at 10:30 a. m.

THE PRESIDENT: We will now start the proceedings of the twenty-third annual convention, and I will call upon Mayor Raymond, who is well known thru this part of the United States, to address us.

MAYOR THOMAS L. RAYMOND: Mr. President and Gentlemen of the American Society of Municipal Improvements: I extend to you a most hearty and cordial welcome to Newark, and in doing so I wish to say how proud we are to have you come here and meet here and use this as your convention city. We have only lately been able to receive conventions such as this, because of the recent opening of the hotel, and now we feel we can make you as happy and as comfortable as any city in the country. We have had a celebration here for five months of our 250th anniversary. For America we are an old city. In the old world, of course, we are still an infant. But this celebration did much for Newark. It did much for Newarkers themselves, in that it gave them a better point of view, a broader view. And I think a great thing it did for Newark was to open the eyes of the rest of the country and of

Canada to Newark and what Newark is. It is not necessary for me in the presence of experts to talk about Newark today, but I do hope that you will look it over, and I hope you will look at its streets, which I believe are the best streets and the best paved streets in this country. And I hope you will look at our municipal institutions. We have had very able leaders in our engineering department. We have had a Board of Works which has kept the cost down and made the improvements possible. Out of each \$100 which the taxpayers pay for improvements in this city about \$3.50 covers the work of the Board of Works in the streets, cleaning and paving and otherwise, which is a pretty good record, I think.

Now, gentlemen, I welcome you here most cordially and I hand out the proverbial key to you and hope you will use it with discretion. The trouble with this key is that it is now in the possession of two bodies of men, as we have here today in session also the educational people, the Compulsory Education convention. I think the key is safe in their hands, and from what I know of some of our engineering department, I think they are capable of having a good time, and I warn you, that is all. I hope you will like Newark so well that you will come here again to see us and that your stay here will prove successful and pleasant, and that the result of this convention will be of benefit to the great work which you are doing.

MR. TRIBUS: Mr. President, Mayor Raymond, and Guests and Members of the Society: The membership of this Society, sir, is composed of men with a purpose. They have taken to themselves the study of the various problems affecting municipal development and municipal management—municipal housekeeping. They gather from time to time in different parts of the country, they travel to different parts of the world, so as to get the latest information, ideas, opinions, views, and then digest them so as to make the best use of their time and opportunity to help communities grow, to help communities to help themselves. And if in that process they can have a good time, and can acquire much wealth, as you see instances thruout this gathering—so much the better.

They have come this time to meet in the city of Newark, which, as you have said, has had a long history, a very interesting history, a prosperous history, and they wish to join in the congratu-

lations that have been pouring in upon you here during these past months. They hope to spend these few days in accepting the hospitalities and courtesies extended, and will try their best not to overtax them, even though the city's key be handed to them in the most gracious of terms. The city of Newark has taken from our membership some of its most shining lights, and I think you have very properly credited to them some of the large development that this city has had. We are glad to come and see their work and your work. We thank you for your felicitous welcome and thru you the friendly citizenship of the whole city of Newark.

THE PRESIDENT: The next is an address by the President.

PRESIDENT'S ADDRESS.

By ANDREW F. MACALLUM.

In this, our twenty-third annual convention, we are meeting in the home city of several of our past presidents. The commissioners of this city have for a number of years taken a deep interest in the proceedings of our Society, and having always attended the conventions, we may hope to see where they have utilized the information thus gained in the betterment of this city.

The Society has now reached that position in its development that in most cities and in the latest text books upon municipal works the specifications as revised each year are considered as standard. This has been of considerable benefit to municipal engineers not always versed in physical and chemical properties considered necessary in different materials. It has also eliminated the type of specification sent out by commercial institutions which were too often misleading, inasmuch as clauses were written in that either limited competition or made it impossible. By continuing the policy that this Society has always adopted in appointing to the different chairmanships of committees men recognized as authorities in their particular branch of engineering, I have no doubt as to the success that will continue to follow their efforts.

In the majority of municipalities thruout this country the engineers are voted in on a political ticket at each election. In the lack of continuity, different methods adopted, probable change of policy and lack of familiarity in municipal work these municipali-

ties must inevitably suffer. The fact that the man with the best qualifications politically may not be the best one from the standpoint of efficiency is, I believe, slowly but surely dawning upon municipalities and attempts are being made in the appointment of commissioners, city managers, and other forms of civic government to get away from political domination.

It is a matter of common observation that many civic officials do not keep up their information as to what is being done in other cities and towns. Thus, we see the same mistakes repeated time and again and the experience of others, sad and otherwise, lost with consequent financial loss to their municipalities thru their ignorance.

That membership in the American Society of Municipal Improvements will materially assist such men there is no doubt, as besides the information they obtain at the conventions and thru the published proceedings, the discussion with others in their particular line of endeavor will naturally quicken their interest and develop their reading faculty. One of the departments of this Society which I believe should be developed further is that with reference to the clearing house. This department could be broadened out to include research work so far as it is carried out in different cities which are represented by members of this Society and this would have the tendency of eliminating much useless preliminary experimental work. By the collection and distribution of the progress or results of experiments going on it would materially save both time and money.

It is hoped that the members here will attend as many meetings as possible and get to them promptly on time as the program is long, varied and interesting. We are holding this convention in a place where the attractions are many, but we are trusting that the members realize, as no doubt they do, that they should attend all the meetings not only for their own benefit, but for the good of the municipalities which they represent.

We have yet with us the great war that is raging thruout Europe and while it has so far been of great financial benefit to this country, it is also the principal cause for the industrial unrest now so prevalent. The large amount of money made in munitions and

supplies, combined with large wages paid in these places, with the increased cost of living in cities, has naturally caused the demand for increased wages from industrial and traction companies sometimes not directly benefited. What the effect will be at the close of the war is problematical, but many indications are none too favorable and municipalities will be wise not to be too lavish in their expenditures until times become normal again. This applies probably to a greater extent to those of us who come from Canada, where, as a participant, war bears heavily upon us, for nearly one-tenth of the total population is across the sea fighting for the Mother Country, or under training to go there. Most of us who come from there have relatives in the fighting line and all have had friends who have already given their lives that others might live in peace. It is the hope of this Society that before we meet for the next convention we may once more have peace thruout the world.

THE PRESIDENT: We will now have the report of the Executive Committee.

SECRETARY BROWN: The Executive Committee held its regular meeting this morning before the convention, and most of the work which was done will be shown by the Secretary's report. There were 102 applications for membership presented to the Board this morning, in addition to those which will be shown in the report itself, these applications having come in since the last vote, which was sent out the first of September. This will increase the number of members, when they are all taken in, to 653. There will be a later meeting of the Committee, when other matters will be taken up and reported on.

THE PRESIDENT: We will now have the report of the Secretary.

REPORT OF THE SECRETARY.

By CHARLES CARROLL BROWN.

The Secretary presents his report for the year from Oct. 1, 1915, to Sept. 30, 1916, as follows:

The following table gives the membership record for the year:

	Sept. 30 1915	Admitted during year	Lost during year	Membership Sept. 30, 1916
Active	339	89	17	411
Affiliated	11	5	2	14
Associate	106	33	12	127
	<hr/>	<hr/>	<hr/>	<hr/>
Totals	456	127	32	552

The losses of members from all sources consist of the following:

Active:

Resigned	10
Died	1
Mail returned—undeliverable	6
	<hr/>
Total....	17

Affiliated:

Resigned	1
Mail returned—undeliverable	1
	<hr/>
Total....	2

Associate:

Representatives of associate members (6 firms)	10
Mail returned—undeliverable (2 firms)	2
	<hr/>
Total....	12

Total of all grades....32

On Sept. 30 of this year we had 411 active members, including 18 delegates from 10 Municipal Members.

We had 14 affiliated members.

We had 127 associate members representing 81 firms and individuals.

The following cities have credits from the A. S. P. S. paid for by that Society in the amalgamation and not yet taken up by appointment of delegates:

Boston, Mass., 4 delegates;
 Columbus, Ohio, 4 delegates;
 Norfolk, Va., 2 delegates;
 Pasco, Wash., 3 delegates;
 St. Louis, Mo., 1 delegate;
 Salisbury, N. C., 2 delegates;
 S. Omaha, Neb., 3 delegates.

So far as reports have reached the Secretary, one member has died—Robert H. Boynton, City Engineer, Frankfort, Ind., on Sept. 18.

It will be noted that the increase in active membership during the year is 21 per cent. and the increase in total membership a little less than 21 per cent. Including the names of applicants to be voted on at the meeting of the Board at which this report is presented, the increase in active membership for the year is well over 25 per cent.

The accompanying table shows the monthly receipts during the year, classified as to source, and the remittances of the Secretary to the Treasurer. The account runs from Oct. 1, 1915, to Sept. 30, 1916.

The receipts during 1916 were more than the receipts during 1915 by \$638.27.

The expenditures are classified as follows:

Office.

Stenographer	\$ 540.00
Express	17.58
Supplies and miscellaneous.....	13.48
Postage	349.38
	<hr/>
	\$ 920.44

Printing.

1915 programs	\$ 37.75
5,000 booklets (constitution, etc.).....	55.00
Specifications and changes in same.....	107.85
Instructions to committees.....	6.00
Receipt book	10.00

TABULAR STATEMENT OF RECEIPTS BY SECRETARY AND REMITTANCES TO TREASURER.

1915 Rect. Nos.	Proceedings Sold				Advt.	Affil.	Membership Dues		Munic.	Remittances to Treas.	
	A.S.M.I.	A.S.P.S.	Specif.	Misc.			Active	Assoc.		Date	Amount
Oct. 3532-3683	22.00	...	17.76	.....	30.00	25.00	462.50	300.00	5.00	11/8	\$ 862.26
Nov. 3684-3701	19.00	5.00	8.50	224.62	.....	....	15.00	.....	....	12/3	272.12
Dec. 3702-3722	4.00	...	7.15	32.11	24.36	....	15.00	10.00	25.00	1/1	117.62
1916											
Jan. 3723-3773	12.00	...	6.90	.....	.....	....	160.00	125.00	....	2/8	303.90
Feb. 3774-3870	2.00	...	12.25	10.00	.....	....	300.15	260.00	5.00	3/6	589.40
Mar. 3871-3911	10.00	...	73.51	.....	.....	....	117.50	25.00	10.00	4/1	236.01
Apr. 3912-3941	20.50	...	26.75	6.00	190.00	5.00	45.00	.....	....	4/29	293.25
May 3942-3981	47.00	...	5.00	.....	73.00	7.50	47.50	30.00	20.00	5/31	230.00
Jun. 3982-4011	29.00	2.00	6.31	.....	65.00	....	30.00	10.00	....	7/5	142.31
Jul. 4012-4038	6.00	...	13.69	30.17	60.00	....	70.00	20.00	....	8/3	199.86
Aug. 4039-4072	13.00	...	12.51	.....	.....	5.00	87.60	5.00	....	9/1	123.11
Sep. 4073-4114	7.00	...	51.38	.....	20.00	....	157.50	5.00	....	9/29	240.88
Totals	191.50	7.00	241.71	302.90	482.36	42.50	1,507.75	790.00	65.00		\$3,610.72

Cuts for 1915 Proceedings.....	170.91	
Advertising contracts, 1916.....	6.50	
Application blanks	10.50	
Stationery (sec. and committee chmn.).....	147.89	
Reprints (sold at cost).....	39.10	
Proceedings (includes shipping expense but not postage)	1,131.35	
		<hr/> \$1,722.85
<i>Miscellaneous.</i>		
Treasurers' bond	\$ 7.50	
Convention stereopticon	17.50	
Convention expenses secretary.....	35.87	
Reporting convention	85.00	
Convention expenses (local committee).....	70.00	
L. L. Tribus (committee expense).....	10.32	
A. P. Folwell (committee expense).....	141.08	
Secretary's salary	300.00	
Postage on 1915 Proceedings	88.71	
Copyright for Proceedings	1.10	
Paper for advance papers, 1916.....	84.88	
		<hr/> \$ 841.96
Total		\$3,485.25

There is an apparent increase in expenses of 1916 over 1915 of \$135.65, but this is much of it accounted for by the item of paper for 1916 advance papers, \$84.88, which is really an expense of next year. Nearly \$40.00 of this is for paper furnished for a reprint which will be repaid the society.

The totals of receipts and expenditures show an excess of the former of \$172.36, which is satisfactory to the secretary, at least, because it is the first time he has been able to report a surplus from the operations of the society, tho, thanks to other sources of income, there has been an addition to the funds of the society each year.

The cost of printing and distributing the 1915 Proceedings was:

Printing and shipping.....	\$1,131.35
Cuts	170.91

Postage	88.71	
	<hr/>	\$1,390.97

The receipts on account of Proceedings were:

Advertising	\$ 462.36	
Proceedings A. S. M. I. sold...	191.50	
Proceedings A. S. P. S. sold...	7.00	
	<hr/>	\$ 660.86

Deficit	\$ 730.11
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There is still due from advertisers \$59.00. Counting this in the Proceedings cost \$671.11 more than the receipts from that source.

The cost of printing specifications and changes in same was \$107.85. The receipts from specifications sold were \$241.71. The excess of receipts over expenditures on this account was \$133.86, from which the amount of expressage and postage in shipping them should perhaps be deducted.

There are a few miscellaneous unpaid accounts for proceedings and specifications in process of collection amounting to \$32.75.

The following members have been admitted during the year. This list does not include those admitted at the 1915 convention, whose names appear on pages 486-7 of the Proceedings for 1915. Neither does it contain the names of those whose applications were received in October, 1915, and were admitted after the convention of October, 1915, whose names appear on pages 487-8 of the Proceedings for 1915:

Active Members Admitted.

Askwith, F. C., Ottawa, Canada.
 Baechlin Ernest, Bloomfield, N. J.
 Benham, Ernest L., Oklahoma City, Okla.
 Campbell, Edward F., New Rochelle, N. Y.
 Colle, C. E., Greenville, Tenn.
 Collins, Thomas F., Elizabeth, N. J.
 Connell, Wm. H., Philadelphia, Pa. (Municipal Delegate).
 Coward, E. H., Pittston, Pa.
 Cowden, M. H., Harrisburg, Pa. (Municipal Delegate).
 Dallyn, F. A., Toronto, Canada.
 Datesman, George E., Philadelphia, Pa. (Municipal Delegate).
 Davis, C. E., Philadelphia, Pa. (Municipal Delegate).
 Dean, John A., Owensboro, Ky.

Dubuc, Jules H., Montreal, Que.
 Duff, E. E., Sewickley, Pa.
 Flood, Walter H., Chicago, Ill.
 Fugate, Henry C., West Palm Beach, Fla.
 Goldstein, Harry K., Philadelphia, Pa.
 Gray, E. R., Hamilton, Ont.
 Hansell, Jr., Wm. A., Atlanta, Ga.
 Henderson, Charles E., St. Augustine, Fla.
 Horton, Irving S., Reading, Pa.
 Hunter, Lionel McL., Ottawa, Ont.
 Koiner, C. W., Pasadena, Cal. (Municipal Delegate).
 Lee, Loring W., Sumter, S. C.
 Legare, Thos. K., Columbia, S. C.
 Mackie, Geo. B., Moose Jaw, Sask.
 McArthur, Franklin, Guelph, Ont.
 Miller, Daniel J., Bangor, Pa.
 Morgan, L. T., Live Oak, Fla.
 Myers, Wm. G., Harrisburg, Va.
 Parlin, Raymond W., New York City.
 Primeau, A. K., Muskegon Heights, Mich.
 Putnam, Chas. F., Roxbury, Mass.
 Redfern, Ira T., South Orange, N. J.
 Shakman, James G., Chicago, Ill.
 Shea, James B., Jamaica Plain, Mass.
 Shelton, Wm. H., Dunkirk, N. Y.
 Smith, James E., Urbana, Ill.
 Sumner, Charles R., Hermosa Beach, Cal.
 Taylor, Henry C., Wilmington, Del.
 Tries, Jr., Wm., Newark, N. J.
 Varney, Henry A., Brookline, Mass.
 Vars, Alexander W., Plainfield, N. J.
 Webster, Edwin R., Marion, Iowa.
 Webster, G. S., Philadelphia, Pa. (Municipal Delegate).
 Weirbach, Chas. D., Allentown, Pa.
 Weller, W. Earl, Binghamton, N. Y.
 Wilson, W. H., Park City, Tenn.
 Wise, B. A., Bradford, Pa.
 Woodworth, C. A., Ida Grove, Iowa.

Affiliated Members Admitted.

Adam, Carl F., La Crescenta, Cal.
 Bureau of Municipal Research, New York City.
 Lloyd, Alfred O., Chester, S. C.
 MacKenzie, L. R., Clayton, Mo.

Municipal Members Admitted.

Harrisburg, Pa.
 Pasadena, Cal. Municipal Lighting Department.

Associate Members Admitted..

AMIES ROAD COMPANY, Easton, Pa.
 W. T. Newcomb, Easton, Pa.
 Brehm, Harry L., Rep. Warren Bros. Co., Cleveland, O.

Budge, Guy G., Rep. Warren Bros. Co., Cleveland, O.
 Cherrington, Frank W., Rep. Jennison-Wright Co., Toledo, O.
 Church, S. R., Rep. The Barrett Co., New York City.
 CONTINENTAL PUBLIC WORKS CO., New York City.
 W. B. Spencer, New York City.
 Culley, O. L., Rep. Magnolia Petroleum Co., Chicago, Ill.
 Dewine, E. J., Rep. U. S. Asphalt Refining Co., Columbus, O.
 Fletcher, Herbert E., Rep. Hildreth Granite Co., West Chelmsford,
 Mass.
 Forrester, J. D., Rep. John Baker, Jr., Kansas City, Mo.
 Gay, L. W., Rep. John Baker, Jr., Buffalo, N. Y.
 Hogue, W. A., Rep. Warren Bros. Co., Charleston, W. Va.
 Marshall, C. C., Rep. Standard Oil Co. of N. Y., Lakewood, O.
 Miller, J. S., Rep. Barber Asphalt Paving Co., Maurer, N. J.
 Miller, C. H., Rep. Blackmer & Post Pipe Co., St. Louis, Mo.
 Murray, S. R., Rep. John Baker, Jr., Indianapolis, Ind.
 Newcomb, W. T., Rep. Amies Road Co., Easton, Pa.
 Park, Ernest S., Rep. The Rodd Co., Pittsburgh, Pa.
 Patterson, F. W., Rep. Cleveland Trinidad Paving Co., Cleveland, O.
 THE RODD COMPANY, Pittsburgh, Pa.
 Ernest S. Park, Pittsburgh, Pa.
 Sharples, Philip, Rep. The Barrett Co., New York City.
 Smith, B. M., Rep. The Barrett Co., Chicago, Ill.
 Spencer, W. B., Rep. The Continental Public Works Co., New York
 City.
 Valk, James R., Rep. The U. S. Asphalt Refining Co., Chicago, Ill.
 Ware, James T., Rep. John Baker, Jr., Kansas City, Mo.
 Woodruff, J. M., Rep. Warren Bros. Co., Richmond, Va.

The following members have withdrawn during the year:

Active Members Withdrawn.

Resignations:

Alvord, John W., Chicago, Ill.
 Blair, Alexander, Summit, N. J.
 Bennett, Charles J., Hartford, Conn.
 Butler, Morgan R., Waukesha, Wis.
 Farnham, Arthur B., Pittsfield, Mass.
 Kidd, A. L., Boston, Mass.
 McCay, H. K., Baltimore, Md.
 Mitchell, Karl, Sherman, Tex.
 Rourke, L. K., Boston, Mass.
 Stevens, L. E., Grand Rapids, Mich.

Mail Returned:

Erwin, M. C., Dallas, Tex.
 Hale, Wm. C., San Diego, Cal.
 Riter, Geo. W., Salt Lake City, Utah.
 Wills, Joe B., Dallas, Tex.
 Wilson, James, Calgary, Alta.
 Whyman, R. O., Amarillo, Tex.

Died:

Boynton, Robert H., City Engineer, Frankfort, Ind.

*Affiliated Members Withdrawn.***Resignation:**

Griffith, O. J., Little Rock, Ark.

Mail Returned:

Norman, W. H., Dallas, Tex.

*Associate Members Withdrawn.***Resignations:**

Adam, Carl F., Rep. Union Oil Co. of Cal., San Francisco, Cal.

Beistle, M. J., The Barrett Co., Columbus, O.

Bruff, Albert C., Edison Portland Cement Co., Quincy, Mass.

CALIFORNIA BRICK CO., Decoto, Cal.

Claude E. Fuller.

L. R. MacKenzie.

Doane, S. E., National Lamp Works, Cleveland, O.

EDISON PORTLAND CEMENT CO., Quincy, Mass.

Albert C. Bruff.

Fuller, Claude E., California Brick Co., Decoto, Cal.

Loud, Henry S., U. S. Preserving Co., New York City.

MacKenzie, L. R., California Brick Co., San Francisco, Cal.

METROPOLITAN PAVING CO., New York City.

Hugo Reid, New York City.

Miner, H. A., Steel Protected Concrete Co., Philadelphia, Pa.

NATIONAL LAMP WORKS, Cleveland, O.

S. E. Doane, Cleveland, O.

Pond, Robert W., The Barrett Co., Boston, Mass.

Reid, Hugo, The Metropolitan Paving Co., New York City.

STEEL PROTECTED CONCRETE CO., Philadelphia, Pa.

H. A. Miner, Philadelphia, Pa.

UNION OIL CO. OF CAL., San Francisco, Cal.

Carl F. Adam.

Mail Returned:

Briddell, York, Georgia Engineering Co., Clearwater, Fla.

GENERAL CONSTRUCTION CO., Guelph, Ont.

A. E. Rudd, Guelph, Ont.

GEORGIA ENGINEERING CO.

York Briddell, Clearwater, Fla.

Rudd, A. E., General Construction Co., Guelph, Ont.

The following cities have asked permission to use the Standard Specifications of the Society:

Harrisburg, Pa.

Cleveland, O.

Milford, O.

Sewickley, Pa.

Buffalo, N. Y.

Allentown, Pa.

The following were elected to membership at the convention of 1916 or made application at the convention and were elected immediately after it, and are not included in the preceding account of membership, which closed September 30.

ADMITTED AT AND IMMEDIATELY AFTER THE CONVENTION.

Active.

Allen, Henry C., City Engineer, Syracuse, N. Y.
 Aloe, L. P., President Board of Aldermen, St. Louis, Mo.
 Barrett, C. H., Mayor, Gloucester, Mass.
 Bastis, Albert, Municipal Delegate, Minneapolis, Minn.
 Bourleau, Edward, Street Superintendent, Chicopee, Mass.
 Brehm, George C., City Engineer, Waynesboro, Pa.
 Carson, H. O., City Engineer, Butler, Pa.
 Chase, Guy H., Commissioner Streets and Engineering, Fitchburg, Mass.
 Condon, Pierce P., Street Superintendent, Watertown, Mass.
 Cozzens, A. B., Secretary City Plan Commission, Newark, N. J.
 Crowley, J. W., Commissioner of Public Works, Davenport, Ia.
 Currie, C. H., Consulting Engineer, Webster City, Ia.
 Davis, Charles O., Superintendent Street Sanitation, Milwaukee, Wis.
 Denison, Henry S., Chairman Board of Public Works, Framingham, Mass.
 Devlin, Harry, Superintendent of Buildings, Park Department, Bronx, New York City.
 Duchastel, J. A., City Engineer, Outremont, Quebec, Canada..
 Durkin, Patrick, Superintendent of Public Works, Danbury, Conn.
 Emerson, C. A., Jr., Pennsylvania State Department of Health, Harrisburg, Pa.
 Estler, Charles E., Chairman of Road Commission, Boonton, N. J.
 Evers, Henry A., Councilman, Cranston, R. I.
 Fisher, E. A., City Engineer, Lakewood, Ohio.
 Fisk, George F., Assistant Engineer, Bureau of Engineering, D. P. W., Buffalo, N. Y.
 Gault, Matthew, Superintendent of Sewers, Worcester, Mass.
 Goff, Edward E., City Engineer, Cranston, R. I.
 Hamley, S. J., Pittsburgh Testing Laboratory, Cleveland, Ohio.
 Harrison, Edwin M., Director Department of Streets and Public Improvements, Montclair, N. J.
 Hawley, John B., City Engineer, Boonton, N. J.
 Hellman, H. W., Assistant Essex County Engineer, Newark, N. J.
 Helland, Hans, City Engineer, San Antonio, Tex.
 Johnson, George A., Consulting Engineer, New York City.
 Jones, Richard A., Street Superintendent, Waltham, Mass.
 Kappele, A. P., Secretary Works Department, Hamilton, Ontario, Can.
 Kemper, Joseph, City Engineer, Utica, N. Y.
 Kennedy, W. E., Superintendent of Streets and Sewers, Waterbury, Conn.
 Knapp, N. A., Superintendent of Highways, Greenwich, Conn.
 Kneale, Robert D., Consulting Engineer, Atlanta, Ga.
 Kraus, Jaros, Architect, Park Department, Flushing, N. Y.
 Lamb, Richard, Consulting Engineer, New York City.
 Marchant, Kilby I., Street Superintendent, Gloucester, Mass.
 May, E. A., Consulting Engineer, Patchogue, L. I., N. Y.
 McCandless, Robert, Clerk, Street Department, New Rochelle, N. Y.
 McCarthy, John J., Acting Purchasing Agent, Department of Parks, Brooklyn, N. Y.
 McCarthy, P. A., City Engineer, Lufkin, Texas.
 McClelland, Richard J., City Engineer, Kingston, Ontario, Canada.
 McComb, Dana Q., Testing Engineer, Pittsburgh Testing Laboratory, Miami, Fla.

McCoubry, Thomas, President Board of Aldermen, Chicopee, Mass.
 McMahon, Patrick F., Highway Commissioner, Brockton, Mass.
 MacDonald, George E., Chairman Overseers of the Poor, Gloucester, Mass.
 Moorhouse, Wm. B., Justice Peace, Member Town Board, Tarrytown, N. Y.
 Meigs, Joseph V., Chemist, City of Boston, Mass.
 Morales, Louis, Chief Engineer, Bureau of Water Supply, Havana, Cuba.
 Parker, E. E., City Engineer, Madison, Wis.
 Pickersgill, H. M., Superintendent of Public Works, Elmira, N. Y.
 Plunkette, J. L., City Engineer, Rome, N. Y.
 Rowland, H. A., City Engineer, McPherson, Kansas.
 Schmieder, Charles, Assistant Architect, Department of Parks, New York City.
 Sherron, George Austin, Street Commissioner and City Engineer, Norwalk, Conn.
 Simmons, Fred G., Commissioner of Public Works, Milwaukee, Wis.
 Simons, F. F., Boro Engineer, Carteret, N. J.
 Sloman, Arthur L., City Manager, Albion, Mich.
 Smith, A. P., Councilman, Boonton, N. J.
 Smith, Fred E., Surveyor of Highways, Rockport, Mass.
 Snow, Hubert A., Chairman Highway Commission, Brockton, Mass.
 Starks, W. Fred, County Superintendent of Highways, Glen Cove, N. Y.
 Swan, Abram, Jr., Engineer Streets, Trenton, N. J.
 Terry, Alfred H., City Engineer, Bridgeport, Conn.
 Thayer, Joel A., Superintendent of Streets, Taunton, Mass.
 Thier, J. Ernest, Supervisor of Roads, Montvale, N. J.
 Truss, J. D., Commissioner of Public Improvements, Birmingham, Ala.
 Upton, Sam F., Clerk, Street Department, New Rochelle, N. Y.
 Warman, H. S., Superintendent of Weights and Measures, Boonton, N. J.
 Waterman, F. V., Town Engineer, East Providence, R. I.
 Webber, B. B., City Engineer, Oil City, Pa.
 White, Henry H., City Engineer, Muskogee, Okla.
 Wulff, Edward J., Consulting and Construction Engineer, Tarrytown, N. Y.

Municipal.

ST. LOUIS, MO.
 Wm. E. Rolfe, Associate to President Board of Public Service.
 NEWARK, N. J., Board of Chosen Freeholders, Essex County, 10 Representatives.
 George Eager, Millburn, N. J.; Ernest E. Ryman, Francis B. Knott, Richard F. Mattia, William Pennington, Thomas W. Smith, Newark, N. J.; William Cardwell, East Orange, N. J.; Alexander Clark, Orange, N. J.; Amos W. Harrison, Livingston, N. J.; August L. Lacombe, Irvington, N. J.
 NEW ORLEANS, LA., 5 Representatives.
 E. A. Christy, W. J. Hardee, Edward F. Lafaye, Foster Olroyd, Thomas L. Willis.
 NORFOLK, VA.
 W. H. Taylor, Jr.
 SALISBURY, N. C.
 J. E. Ramsey.
 RUTHERFORD, N. J.
 Fred W. Sheaf, President Boro Council.

Affiliated.

- Kopf, C. J. Ex-Mayor, Boonton, N. J.
Masury, Alfred F., Chief Engineer, International Motor Company,
New York City.
Routh, J. W., Chief Engineer, Bureau of Municipal Research, Roch-
ester, N. Y.
Wise, Henry A., Engineer, Kansas City Stock Yards, Kansas City, Mo.

Associate.

- AMERICAN CAR SPRINKLER CO., Worcester, Mass.
E. D. Perry, Assistant General Superintendent.
ARABIA GRANITE CO., Atlanta, Ga.
Fred C. Mason, Secretary and Treasurer.
ASPHALT AND SUPPLY CO., Montreal, Que., Can.
W. Alfred Morris, Engineer.
BARBER ASPHALT PAVING CO., Additional Representatives.
Charles W. Bayliss, Philadelphia.
G. R. March, Philadelphia.
THE BARRETT COMPANY, Additional Representative.
M. J. Beistle, Cleveland, O.
BOOTH BROS. & HURRICANE ISLE GRANITE CO., New York City.
Charles Mitchell, Treasurer.
DUSTOLINE FOR ROADS CO., Summit, N. J.
Edwin R. Lamson, President.
JAMES FERRY & SONS, Inc., Atlantic City, N. J.
James V. Ferry, Treasurer.
B. CHARLES HVASS, New York City.
THE IMPERIAL OIL CO., Ltd., Toronto, Ont., Can.
E. D. Gray, Toronto, Ont., Can.
H. A. MORGAN, care the Dorr Company, New York City.
NORTH CAROLINA GRANITE CORPORATION, Mt. Airy, N. C.
Thomas Woodroffe, Vice President and General Manager.
REPUBLIC CREOSOTING CO., Additional Representatives.
A. E. Larkin, Minneapolis, Minn.
Lawrence E. Hess, Indianapolis, Ind.
SEWER PIPE MANUFACTURERS ASSOCIATION, Akron, Ohio.
John L. Rice, Akron, Ohio.
WARREN BROTHERS CO., Additional Representative.
J. H. Lippincott, Newark, N. J.
WATER WORKS EQUIPMENT CO., New York City.
W. H. Van Winkle, Jr.
WESTPORT PAVING BRICK CO., Baltimore, Md.
John W. Hall.

THE PRESIDENT: We will now have the Treasurer's report.

TREASURER'S REPORT.

BY WILL B. HOWE.

Receipts.

By balance from 1915.....	\$1,480.29
November 6, Charles C. Brown, Sec'y.....	362.26
December 6, Charles C. Brown, Sec'y.....	272.12
January 6, 1916, Charles C. Brown, Sec'y.....	117.62
February 11, 1916, Charles C. Brown, Sec'y.....	303.90
March 8, 1916, Charles C. Brown, Sec'y.....	589.40
April 8, 1916, Charles C. Brown, Sec'y.....	236.01
May 1, 1916, Charles C. Brown, Sec'y.....	293.25
June 2, 1916, Charles C. Brown, Sec'y.....	230.00
July 8, 1916, Charles C. Brown, Sec'y.....	142.31
August 7, 1916, Charles C. Brown, Sec'y.....	199.86
September 11, 1916, Charles C. Brown, Sec'y.....	123.11
October 2, 1916, Charles C. Brown, Sec'y.....	240.88
Total	\$5,091.01

Paid Out.

October 20, 1915, U. S. Photo-Engraving Co., cuts, etc., for proceedings	\$46.89
November 8, 1915, F. B. Neff Printing Co., supplies and printing	45.50
November 8, 1915, U. S. Photo-Engraving Co., cuts, etc., for proceedings	15.43
November 8, 1915, Morrill & Danforth, premium on treasurer's bond	7.50
November 8, 1915, Projection Equipment Co., stereopticon and operator	17.50
November 8, 1915, Charles C. Brown, convention expenses....	35.87
November 8, 1915, Charles C. Brown, Sec'y, office expenses...	52.77
December 7, 1915, Central Law Reporting Co., reporting convention	85.00
December 7, 1915, U. S. Photo-Engraving Co., etchings, etc....	36.85
December 7, 1915, Charles C. Brown, Sec'y, office expenses...	70.32
January 8, 1916, F. J. Cellarius, expenses, clerical help, etc....	70.00
January 8, 1916, L. L. Tribus, committee expenses.....	10.32
January 8, 1916, O'Daniel & Russell Engraving Co., cuts.....	45.00
January 8, 1916, Premier Printing Co., supplies, letter heads, etc.	65.75
January 8, 1916, William W. Hampton, box files.....	1.05
January 8, 1916, Charles C. Brown, Sec'y, office expenses....	50.80
February 14, 1916, William W. Hampton, supplies.....	1.05
February 14, 1916, O'Daniel & Russell Engraving Co., cuts....	3.68

February 14, 1916, U. S. Photo-Engraving Co., cuts.....	17.21
February 14, 1916, Printing Arts Co., specifications, etc.....	58.50
February 14, 1916, Charles C. Brown, office expenses.....	81.82
March 10, 1916, U. S. Photo-Engraving Co., halftone.....	1.35
March 10, 1916, Printing Arts Co., etchings.....	1.50
March 10, 1916, Premier Printing Co., supplies.....	77.39
March 10, 1916, Charles C. Brown, Sec'y, office expenses.....	49.00
April 4, 1916, Premier Printing Co., stationery for officers, etc.	29.25
April 4, 1916, Cameron & Buckley, committee stationery.....	30.00
April 4, 1916, Charles C. Brown, Sec'y, office expenses.....	55.73
April 28, 1916, Charles C. Brown, Sec'y, account salary.....	100.00
May 2, 1916, Printing Arts Co., proceedings (printing).....	1,053.85
May 2, 1916, Charles C. Brown, Sec'y, office expenses.....	62.45
May 26, 1916, A. Prescott Folwell, committee expenses.....	73.08
June 5, 1916, William Hampton, loose-leaf binder.....	1.40
June 5, 1916, Frank F. Lisiecki, committee printing.....	64.00
June 5, 1916, National Fac-Simile Letter Co., letters.....	4.00
June 5, 1916, Printing Arts Co., mailing proceedings, printing..	143.66
June 5, 1916, Franklin Press, receipt book.....	10.00
June 5, 1916, Charles C. Brown, Sec'y, office expenses.....	59.43
July 13, 1916, F. B. Neff Printing Co., binding specifications...	3.75
July 13, 1916, Charles C. Brown, Sec'y, office expenses.....	55.00
August 10, 1916, Printing Arts Co., inserts and reprints.....	124.10
August 10, 1916, F. B. Neff Printing Co., printing.....	6.50
August 10, 1916, Charles C. Brown, Sec'y, office expenses.....	84.84
September 13, 1916, F. B. Neff Printing Co.....	3.25
September 13, 1916, Charles C. Brown, Sec'y, office expenses..	67.77
September 13, 1916, Charles C. Brown, Sec'y, balance salary..	200.00
October 2, 1916, West Virginia Pulp and Paper Co., paper.....	84.88
October 2, 1916, Charles C. Brown, Sec'y, office expenses.....	220.26
Total	\$3,485.25
Receipts	5,091.01
Expended	3,485.25
Unexpended balance.....	\$1,605.76

THE PRESIDENT: Next will be the report of the Finance Committee.

The report was read by the Secretary, as follows:

REPORT OF FINANCE COMMITTEE

The Finance Committee would respectfully report that they have examined the books and reports of the Secretary and Treasurer and find them to be correct and in agreement.

The report shows:

Balance from last year.....	\$1,480.29
Receipts during year.....	3,610.72
	<hr/>
	\$5,091.01
Disbursements	3,485.25
	<hr/>
Balance	\$1,605.76

Respectfully submitted,
 EDWARD S. RANKIN, Chairman.
 F. J. CELLARIUS.

THE SECRETARY: I neglected to say with reference to the report of the Executive Committee that they recommended to the Association the appointment of a committee on place of meeting, to take the invitations which we have and report a recommendation regarding them at the proper time on Wednesday.

THE PRESIDENT: I now ask the Society to nominate five members to form this committee.

MR. HOWARD: I would move that all past presidents of this Society be placed on that committee, they are so representative and so experienced. I do not mean it to be confined to them, but have those that are present placed on that committee.

THE PRESIDENT: If there is no objection, it will be so ordered.

We will now have the report of the Special Committee on Standard Tests for Bituminous Materials, by Prof. A. H. Blanchard, Chairman, of Columbia University.

The report read by Professor Blanchard will be found on page 104.

MR. HUBBARD: Mr. President, I move that this report be accepted and placed on file.

Motion seconded by Mr. F. P. Smith, and adopted.

THE PRESIDENT: A Committee on Nominations is to be named.

The following Committee on Nominations was agreed to: Chairman, Frederick Giddings; E. H. Christ, E. A. Kingsley, E. A. Fisher, E. L. Dalton.

THE PRESIDENT: We will now call for nominations for members of Committee on Resolutions.

The following were named: Linn White, A. Prescott Folwell, E. L. Dalton, Frederick A. Reimer, R. K. Compton.

THE PRESIDENT: We will now have a paper on "The Engineer and the Public," by Edward T. Paxton, Austin, Texas.

The paper and discussion will be found on page 524.

THE PRESIDENT: The next is a paper by Mr. Paul Hansen, but I understand he is not here, and we will pass that.

The next paper, "The Relation of Improvement Commissions and the Public with Municipal and Civil Authority," by Mr. William Penn Slifer, Consulting Civil Engineer, of Philadelphia, will be read by its title.

The last paper to be considered is "City Management," by Mr. C. A. Bingham, Norwood, Mass.

THE SECRETARY: Mr. Bingham is not here, but he has sent his paper, so if you like it can be read.

THE PRESIDENT: That paper will be read by its title also.

Adjournment.

EVENING SESSION.

The convention was called to order by the President at 8:45 p. m.

THE PRESIDENT: The first number on our program tonight is the Report of Committee on Water Supply, J. Walter Ackerman, Chairman, which will be read by the Secretary.

The report, read by Secretary Brown, will be found on page 486.

THE PRESIDENT: The next is a paper, "Some Notes on Breaks in Cast Iron Pipe Lines," by R. De L. French.

The paper by Mr. French and the discussion will be found on page 493.

THE PRESIDENT: The next paper is "The Scientific Cleaning of Settling Basins," by Alexander Potter.

The paper read by Mr. Potter, illustrated by several lantern slides, and the discussion will be found on page 498.

THE PRESIDENT: We will now go to the next, lantern slide views and description of Newark water plant, by the greatest city engineering department the city of Newark has ever known.

MR. SHERRERD: Mr. President, after such an introduction I am so embarrassed I do not know where to begin.

Mr. Sherrerd's address will be found on page 512. It was illustrated by a number of lantern slides.

THE PRESIDENT: The report of the Committee on Municipal Legislation will be read by title and the report of the Committee on City Planning will not be given as the chairman, Mr. Parker, is not here. Mr. Kingsley's report will be given tomorrow, and so we come to the last paper for this evening, "Highway Construction in the Northwest," by George C. Warren, of Boston.

A report of Mr. Warren's address, which was illustrated by moving pictures and lantern slides, will be found on page 150.

Adjournment.

WEDNESDAY, OCTOBER 11, 1916

MORNING SESSION.

The meeting was called to order by President Macallum at 9:30.

THE PRESIDENT: There is a short report left over from last night, and Mr. Kingsley will give that now, "Report of Committee on Street and Sidewalk Design."

Mr. Kingsley's report will be found on page 157.

THE PRESIDENT: We will now go on with the first paper on this morning's program, "Disposal of Garbage: a Large City's Problem," by Mr. Tribus. He is not present now, and the paper is printed in the advance papers, so we will pass to the next, "Garbage Collection and Incineration in Sewickley," by Edward E. Duff, Boro Engineer.

The paper read by Mr. Duff will be found on page 253.

THE PRESIDENT: There are three or four papers on garbage collection and disposal, and the discussion will be had after they have all been read or presented. The next paper is "Practicability and Comparative Cost of Collecting Garbage and Refuse with Motor-driven Apparatus, as Compared with Horse-driven Apparatus," by Mr. Miller, of Meadville, Pa. As Mr. Miller is not here we will pass on to the next paper on Garbage and Refuse Disposal, by Mr. Gustave R. Tuska, of New York City. Mr. Tuska is present, but not in the room, and we will pass to the next, "Some Public Health Aspects of Refuse Collection and Disposal," by Mr. Chas. Saville, Dallas, Tex.

MR. CONANT: Mr. Saville was not able to come to the convention, and sent me a paper, which, if time were very limited, I would read by subject only, but it has one or two good thoughts in it and I think it is worth touching upon them.

The paper as read by Mr. Conant will be found on page 278.

THE PRESIDENT: As Mr. Tuska is now present, we will have his paper.

Mr. Tuska's paper and discussion will be found on page 265.

THE PRESIDENT: These three papers and also the paper by Mr. Tribus are now open for discussion.

The discussion will be found on page 273.

THE PRESIDENT: There were one or two matters that were passed at the beginning of the meeting this morning, and the first is the election of officers.

MR. KINGSLEY: The Chairman of our committee, Mr. Giddings, is not able to be on hand this morning, having been taken quite ill yesterday afternoon, and I will submit for him, as secretary of the committee, the report.

REPORT OF COMMITTEE ON NOMINATIONS

Newark, N. J., October 11, 1916.

To the Members of the American Society of Municipal Improvements, in Convention, Newark, New Jersey:

Gentlemen—Your Committee appointed to recommend nominees for the various elective offices for the incoming year, submit to the Convention the following nominations, to wit:

For President—

Mr. Norman S. Sprague, Pittsburg, Penna.

For First Vice-President—

E. R. Conant, Savannah, Ga.

For Second Vice-President—

G. H. Norton, Buffalo, New York.

For Third Vice-President—

R. K. Compton, Baltimore, Md.

For Secretary—

Charles C. Brown, Chicago, Ill.

For Treasurer—

F. J. Cellarius, Dayton, Ohio.

For Finance Committee, as follows—

G. A. Carpenter, Pawtucket, R. I.

F. A. Reimer, East Orange, N. J.

Hal Moseley, Dallas, Tex.

Respectfully submitted,

Fred Giddings, Chairman,

E. L. Dalton,

E. A. Fisher,

E. H. Christ,

E. A. Kingsley.

On motion, duly seconded, the recommendation of the committee was unanimously adopted and the respective officers as named by the committee were elected.

THE PRESIDENT: The next is the selection of our next place of meeting.

REPORT OF COMMITTEE ON NEXT PLACE OF MEETING

American Society of Municipal Improvements:

Gentlemen—Your committee appointed to consider and report upon the invitations received by this society for the convention of 1917, begs to report as follows:

Invitations have been received from fifteen cities as follows: Asbury Park, N. J., Buffalo, N. Y., Chicago, Ill., Columbus, O., New Haven, Conn., New Orleans, La., Norfolk, Va., Portland, Ore., St. Louis, Mo., San Antonio, Texas, San Francisco, Cal., Savannah, Ga., Syracuse, N. Y., Toledo, O., and Worcester, Mass. The invitations from the several cities were given by the following officials or organizations: Asbury Park, Mayor and Director of Public Affairs. Chicago, Association of Commerce. Columbus, Conventions and Publicity Association. New Haven, Chamber of Commerce. New Orleans, Mayor Behrman; Association of Commerce, and William J. Hardee, a member of this Society. Norfolk, Chamber of Commerce. Portland (Ore.), Chamber of Commerce. St. Louis, the Mayor; the Convention and Publicity Bureau; the Associated Retailers, and the Merchants Exchange. San Antonio, the Mayor; Chamber of Commerce, and E. A. Kingsley, Past President of the Society. San Francisco, the Convention League. Savannah, the Mayor and Aldermen; the Tourist and Convention Bureau; Board of Trade, and E. R. Conant, Third Vice President of the Society. Syracuse, the Chamber of Commerce. Toledo, the Convention and Tourist Bureau. Worcester, the Chamber of Commerce.

A number of these invitations go into detail in setting forth the advantages of the city in question and reasons for our selecting it for our 1917 convention. Among these is the statement by Mr. Hardee, that since 1914 the Society had been practically committed to accept the invitation of New Orleans in 1917, being then already in a way pledged to Dayton for 1915 and Newark for 1916. This being the opinion of your committee also, and in view of the particularly cordial invitation offered by New Orleans and of our belief that it would serve excellently as a meeting place for this Society, and further in view of the fact that it has been several years since we have held a convention within easy traveling distance of

our Southern members, we recommend that the Society accept the invitation of New Orleans for its convention next year.

Respectfully submitted,

E. A. Fisher.	E. A. Kingsley.
A. P. Folwell.	E. H. Christ.
Charles C. Brown.	W. A. Howell.
M. R. Sherrerd.	James Owen.
Julian Kendrick.	Geo. W. Tillson.
Fred Giddings.	

THE SECRETARY: Mr. President, at the request of Capt. Hardee, I wish to read the letters which come from the city of New Orleans transmitting its invitation.

October 4, 1916.

President and Members American Association of Municipal Improvements, Newark, N. J.

Gentlemen: On behalf of the city of New Orleans I have the honor to invite you to hold your 1917 annual meeting in the city of New Orleans, assuring you that our citizens will extend to the members and their families the full limit of hospitality for which our old city is so well renowned.

We have a number of unique municipal features, some of which have been completed and others in progress, totally dissimilar to anything of their kinds elsewhere thruout the country, and I feel certain that you gentlemen will be much interested in examining these various improvements.

Trusting that this invitation will be accepted, I am,

Yours very truly,

MARTIN BEHRMAN, Mayor.

September 27, 1916.

The American Society of Municipal Improvements, Newark, N. J.

Gentlemen: The New Orleans Association of Commerce, an organization of several thousand business, professional and scientific men, extends to your body a most cordial invitation to hold its

next annual meeting in New Orleans, and we trust this invitation will be given consideration when the matter of the next convention city is taken up.

Your members will be welcomed here, not only by a most hospitable people, but also by a community which is doing some big things in a big way. Economic problems of great magnitude and far reaching importance are being worked out here.

It is perhaps needless for us to further enumerate the many advantages and attractions this city offers, and the reasons why it would be a desirable meeting place, except to state that the hospitality of a city which stands out predominantly as a community where the stranger within her gates is made to feel at home, awaits you, and if you should decide to hold your next meeting here, nothing will be left undone to make it the most successful in the history of the organization.

A meeting in New Orleans would also give those of your members so inclined, an opportunity to make a side trip to Panama. The Canal is within four and a half days from New Orleans.

We sincerely hope this city will have the good fortune of welcoming you next year.

Yours very truly,

ERNEST LEE JAHNCKE, *President.*

October 2, 1916.

To the President and Members, American Society of Municipal Improvements, Newark, N. J.

Gentlemen: We understand that an invitation has been issued to your Society, through his honor, the Mayor, to hold your next meeting in New Orleans.

The Grunewald is pleased to place at your disposal without charge, its Convention Hall, meeting rooms, and such other rooms for committees as may be required for the proper conduct of your business session during this meeting.

For the delegates and their families or friends who intend

accompanying them to this convention, we are pleased to make the following special rates:

In the New Annex.

Room without bath, one person.....	\$2.00 per day
Room without bath, two persons.....	3.00 " "
Room with bath, one person.....	4.00 " "
Room with bath, two persons.....	5.00 " "

In the Main or Old Bldg.

Room without bath, one person.....	1.50 " "
Room without bath, two persons.....	2.50 " "
Room with bath, one person.....	3.00 " "
Room with bath, two persons.....	4.00 " "

Anticipating the pleasure of entertaining your convention, beg to remain,

Yours very truly,

"THE GRUNEWALD"

John Grunewald.

MR. KINGSLEY: Mr. Helland, city engineer of San Antonio, and myself have come here thinking that we might be able to take this convention back to our Southern city. It is another one of those Panama cases—it is a week-end side trip from New Orleans over to San Antonio, so we hope if you come to New Orleans many of you will come to see our beautiful little Texas city. We found when we got here that Capt. Hardee had been here before us, not particularly this year, but for several years, and so many of the new members had really desired to go to New Orleans that we decided the wise thing to do was to give up in behalf of New Orleans. And so, Mr. President, I want to move that the invitation of New Orleans, as recommended by the Committee, be accepted by the Association for next year's meeting.

MR. NORTON: Mr. President, I desire to second that motion, and in doing so wish to state, as I did when I extended the invitation from the city of Buffalo last year, that Newark seemed to have it all buttoned up, and what's the use. I wish to call the attention of this convention to the fact that there is going to be another year after 1917, which is 1918, and I believe that

this Society had its birth in Buffalo 25 years previous to that date, and if things work favorably Buffalo wants to be on the map for the quarter centennial of this Association.

THE SECRETARY: I want to add one point more. The city of New Orleans has made application for 34 members from the city departments and they have been elected as members of the Association.

The motion was duly passed.

MR. HARDEE: On behalf of the mayor and the citizens of New Orleans in general I want to thank the Society for having selected New Orleans as its 1917 place of meeting. I feel safe in assuring you gentlemen that all of the promises contained in the communications of the mayor and the Association of Commerce will be fulfilled, and I further feel certain that you will all have a good time and go away from New Orleans wishing to get back there soon.

THE PRESIDENT: The next three papers are on street cleaning. The first is "Street Cleaning of Savannah, Ga., Method Employed, Cost Data, etc." by E. R. Conant.

Mr. Conant's paper will be found on page 283.

THE PRESIDENT: The discussion on this paper and the next two papers as well will be taken up together at the close. The next is "Problems and Methods in Snow Removal and Disposal," by H. S. Richards. Mr. Richards is not here, his paper is printed in the advance papers, so we will pass to "Flushing: Its Place in the Street Cleaning Field," by Raymond W. Parlin, New York City.

MR. PARLIN: I am sorry that the lanterns are not working, for I simply intended to show some pictures to illustrate a few points. Since we can not have the lantern, I will simply touch the high points in the paper.

Mr. Parlin's paper will be found on page 297.

THE PRESIDENT: These papers are now open for discussion. I see Mr. Laberge here, of Montreal, and I would like to hear what he may have to say on the subject of snow removal.

MR. LABERGE: Mr. Chairman, I am sorry, indeed, I have no data as to snow removal. Altho I belong to the city of Montreal, I do not belong to the staff of the city, and I have no occasion to know exactly what snow removal costs Montreal. But I know, for I have seen it done there in the last three or four years, that they have extensively used the sewers to dump the snow collected on the streets. At first we thought it was an impossibility but I think it has worked very satisfactorily. If the city engineer were here he could give you the data. I know it has diminished the cost of the snow removal to the extent of a very good sum. I am very thankful that you asked me to speak on the matter, but I have no data or statistics.

THE PRESIDENT: Next is the Report of the Committee on Parks and Parkways, by Mr. Sprague, which will be passed as he is not here now. "American Park Systems," by Mr. Sheridan, will be illustrated by lantern slides, and we will have to put that on at the evening session instead of today. The same applies to "Necessity for Limiting the Loads, Speed and Size of Vehicles," by Mr. Stern, which is also to be illustrated with slides. "The Care of Birds in Public Parks" is in the advance papers, and the author is not present, so that paper will be read by title. That leaves the Report of Committee on Traffic and Transportation on a Proposed Standard Form of Making Traffic Counts, by Mr. Hallock.

Mr. Hallock's report as read will be found on page 213.

THE PRESIDENT: That completes this morning's program, and we will now adjourn to 2 o'clock this afternoon, sharp.

AFTERNOON SESSION.

The meeting was called to order at 2 o'clock.

THE PRESIDENT: We have a couple of papers with lantern slides left over from this morning, on account of lack of lantern service, and the first one will now be taken up, "American Park Systems," by Lawrence V. Sheridan.

The paper of Mr. Sheridan will be found on page 162.

THE PRESIDENT: We will now call on Mr. Stern for his paper on "Necessity for Limiting the Loads, Speed and Size of Vehicles."

The paper of Mr. Stern will be found on page 219.

THE PRESIDENT: I think we will have to postpone discussion on this paper, because we are to take up the report of the Sewage Disposal Committee, by George A. Carpenter, the Chairman, City Engineer of Pawtucket, R. I.

Mr. Carpenter's report will be found on page 324.

THE PRESIDENT: The next is "Sewage Treatment by Aeration and Activation," by George T. Hammond, Brooklyn.

The paper presented in abstract by Mr. Hammond and illustrated with lantern slides will be found on page 327 and the discussion on page 439.

THE PRESIDENT: There are several papers, as you will notice, on this subject, and we will withhold discussion until the papers have been read because in all probability some of the questions to be asked will be answered in the remaining papers. The next one is "A Year's Progress in Activated Sludge Sewage Treatment," by T. Chalkley Hatton, of Milwaukee.

Mr. Hatton's paper, presented in abstract, will be found in full on page 404 and the discussion on page 439.

THE PRESIDENT: The next, "A Few Figures on the Building and Operation of the Baltimore Disposal Plant and Notes on Activated Sludge Experiments," by Gustav J. Requardt, of Baltimore.

MR. REQUARDT: Owing to the limited time, I will not read my paper, but will just give you a general statement of it.

Mr. Requardt's paper will be found on page 416 and the discussion on page 439.

THE PRESIDENT: The next is, "Digestion of Activated Sludge," by Harrison P. Eddy, of Boston.

The paper as presented by Mr. Eddy will be found on page 429 and the discussion on page 439.

THE PRESIDENT: The last paper that we will have this afternoon is "Experience and Results of Four Years' Operation of Imhoff Tanks, Coarse Screens, Fine Screens, and Trickling Filters," by Charles C. Hommon, of Atlanta, Ga.

Mr. Hommon's paper and the discussion will be found on page 464.

THE PRESIDENT: These papers will be taken up for discussion tomorrow morning at 9 o'clock, and we will now adjourn.

THURSDAY, OCTOBER 14, 1915.

MORNING SESSION.

The meeting was called to order by President Macallum at 9 o'clock.

THE PRESIDENT: We will first have discussion of the papers on sewage disposal which were read yesterday afternoon.

These papers will be found on pages 327, 404, 416, 429, and the discussion on page 439.

THE PRESIDENT: If there is no further discussion, we will go on to the next, "Report of Committee on Street Paving, on Present Practice Regarding Replacement of Cuts in Pavements," by Horace Andrews, Chairman.

MR. WARREN: Mr. President, in the absence of Mr. Andrews I would move that that paper be read by title and passed.

Mr. Andrews' report will be found on page 9.

THE PRESIDENT: It is in the advance papers. So we will go on to the next, "The Passing and Conservation of Macadam City Streets and Country Roads," by George C. Warren.

MR. WARREN: Mr. President, I would also move that that, having been published in the advance papers, be read by title, and in connection with it I wish to make a brief statement.

Mr. Warren's paper and the statement will be found on page 134.

THE PRESIDENT: These two papers along with Mr. Stern's

paper yesterday on "The Necessity for Limiting the Loads, Speed and Size of Vehicles," are now open for discussion.

The discussion will be found on page 231 and the paper on page 219.

MR. HANSELL: Along the line of the suggestion made by one of the previous speakers, if there is no committee to handle this, I would move that a committee be appointed to draft laws and rules governing motor truck traffic that could be recommended.

THE PRESIDENT: The Transportation Committee takes this question up.

MR. HANSELL: Then I would move that it be referred to the Transportation Committee.

The motion was seconded by Mr. Pollock and adopted.

THE PRESIDENT: I will now call on W. P. Blair, to present his paper on "Business System Applied to Street and Road Management."

Mr. Blair's paper will be found on page 127.

THE PRESIDENT: The meeting will now adjourn until 8 o'clock this evening.

EVENING SESSION.

The meeting was called to order at eight o'clock p. m.

THE PRESIDENT: The first paper this evening is one left over from this morning, "The Resurfacing of Old Brick Pavements with Sheet Asphalt at Columbus, Ohio," by T. H. Brannan.

Mr. Brannan's paper will be found on page 106.

THE PRESIDENT: If there is no discussion on this, we will pass to the program of the evening. The first paper this evening is on "The Proper Oil for Treating Creosoted Wood Blocks for Paving," by P. C. Reilly, of Indianapolis.

MR. FISHER: Mr. President, I move that the report of the Committee on Standard Specifications be taken up at this time.

The motion was seconded and carried.

THE PRESIDENT: We will hear, then the report of the Committee, George W. Tillson, Chairman.

MR. TILLSON: Mr. Chairman, the Committee on Standard Specifications has no written report to present. It feels that on a subject like this, no matter if standard specifications are adopted now, they are likely to require change at the next meeting, and for that reason we feel that it will be necessary to keep a permanent committee on each one of these kinds of pavement, to report possible suggested changes during the year following each meeting. It feels that after specifications have been adopted, as most of ours have been, that it will be the province of the committees to make suggested changes, so that in subsequent meetings it will not be necessary to discuss specifications as a whole but only the proposed changes. And that is the method which the general committee proposes to adopt this evening. That is, to call upon the chairmen of the different sub-committees and let them make their reports, and then have them come up for disposal at the meeting.

Now, I want to say that in this continuous performance that I have outlined, what the different committees wish is for people who are interested in the specifications, people who want changes in the specifications, to communicate with the committee during the year and not wait until the last moment when the committee meet for the convention or when the report comes up before the meeting. We had at the last meeting two forms of specifications that were laid over for this meeting for final action, and the specifications were published with a request that any one who proposed any changes would communicate with the chairman of the general committee or with the chairman of the particular sub-committee handling the subject in which any one might be interested. I do not think that a single communication was received. I want to impress this fact upon the meeting, that if any of you are not satisfied with the action that is taken tonight, take it up with the committee during the year and do not wait until the last minute and then say because the committee does not give you two hours or half an hour that the committee has cut you off and not allowed you to talk. All the sub-committees held meetings on Monday, and they heard everybody, I think, that wanted to talk and then the main committee took up the

propositions of the sub-committees and the sub-committees will make their reports this evening. This change in the program may make it necessary to take them up out of their regular order, and as Mr. Smith is not in the room, I will ask Prof. Blanchard to present the report on Broken Stone and Gravel Roads, for that committee.

REPORT OF SUB-COMMITTEE ON SPECIFICATIONS FOR BROKEN STONE AND GRAVEL ROADS.

Your Sub-Committee on "Specifications for Broken Stone and Gravel Roads" herewith respectfully submits its report covering its work during the preceding year.

We are herewith submitting in this report specifications for a gravel road for use by municipalities.

It has been the object of the committee to present in its specifications fundamental principles of construction. In accordance with instructions received at the Wilmington convention in 1913 properties of gravel and definite sizes of materials have been incorporated in our specifications. In this connection it should be stated that the Committee is collecting data upon which to base the inclusion in specifications of a maximum allowable per cent. of loss by wear in an abrasion test. Unfortunately very little reliable information is at hand covering the relationship between abrasion tests on gravel and the use of gravels in service tests. It should be borne in mind that specifications covering properties of materials and certain details of construction must be varied in many cases in order that a given form of construction may be economical and suitable for local conditions. Therefore, the specifications incorporated in our report should serve as guides rather than standards adaptable to all conditions which may be found thruout America.

The work on the calendar of the sub-committee includes the drafting of specifications for a gravel road with a bituminous surface, bituminous gravel pavement, bituminous concrete pave-

ment with a gravel aggregate and revisions as required of specifications heretofore submitted by the sub-committee.

Respectfully submitted,

Arthur H. Blanchard, chairman,
T. H. Brannan,
William H. Connell,
Prevost Hubbard,
H. J. Lenderink,
R. A. Macgregor,
Frederic A. Reimer.

MR. TILLSON: Mr. Chairman, of course it is hardly possible for any one to follow a specification of that character as read and take it as a whole, but I would say that personally I have been over these specifications, and would suggest that they be adopted, subject, of course to the rule that I spoke of before that they can and will be amended wherever it is necessary at the next meeting.

MR. MACGREGOR: Mr. President, I move the adoption of the specification.

The motion was seconded by Mr. Tillson and carried.

The specifications for a gravel road as adopted will be found on page 584.

MR. TILLSON: I would ask that Mr. Christ, Chairman of the Brick Paving Committee, make his report next.

MR. CHRIST: Mr. President and Gentlemen: There have been but few changes in the brick specifications, and I do not know whether any of you would understand the changes from a reading of this report, therefore, the committee has presented the whole specifications again. I can tell you the principal changes. The committee has eliminated the brick size altogether. In line 4, paragraph 1, there has been some difficulty in interpreting the specifications which gave the sizes. It says that they shall not vary $\frac{1}{8}$ of an inch in width. That alludes to the brick to be used in any one improvement. We therefore inserted these words, "one from another." The committee also clarified the lug proposition.

We have inserted four lugs, any one lug not to exceed $\frac{1}{2}$ inch in area.

During the last year there have been a number of trucks in use for unloading brick. They worked very satisfactorily, therefore, the committee eliminated the words "by hand," and inserted after "unload," "without spalling or otherwise damaging the brick." This allows the use of a truck.

We have eliminated from the specifications, section 7, 8, 9, 10 and 11, referring to the rattler test and record data and inserted "the rattler test and rattler record data shall conform to the requirements adopted by the American Society of Municipal Improvements in 1914, and all subsequent amendments thereto."

The committee reduced the amount of loam in sand cushion from ten to five per cent.

The committee has added a note to engineers that they recommend a square edge brick. This does not eliminate the radius from the brick, but for bituminous material they prefer a rounded edge.

REPORT OF SUB-COMMITTEE ON SPECIFICATIONS FOR BRICK PAVING.

Your sub-committee on brick specifications respectfully submit the following report:

We recommend that the following changes be made in the brick specifications as adopted by the Society, October 8, 1914, and subsequent amendments.

Under the heading "Character of Brick," in paragraph 1, line 2, strike out the words "vitrified block and" and insert the word "paving."

In line 4 after the word "inch" insert the words "one from another."

In section 1, paragraph 3, line 1, after the word "of" insert the word "paving" and strike out the following words "two and

one-half inches ($2\frac{1}{2}$) in width, four (4) inches in depth and eight and one-half ($8\frac{1}{2}$) inches in length; and the standard size of block."

In section 1, paragraph 3, line 10, after the word "with" insert the word "four." In section 1, paragraph 3, line 11, after the word "inch" insert the following words "nor less than $\frac{1}{8}$ of an inch in height shall be used."

Add to section 1, paragraph 3, the following words: "No one lug shall exceed one-half ($\frac{1}{2}$) inch in area."

In section 2, paragraph 3, line 1 after the word "hauled" insert the word "and" and after the word "unloaded" add the words "without spalling or otherwise damaging the brick."

Under the heading "Making the Rattler Test" strike out all of sections 7, 8, 9, 10 and 11 and insert the following: "The rattler, roller test and record data shall conform to the requirements adopted by the A. S. M. I. in 1914 and all subsequent amendments thereto."

Under the heading "Sand Cushion" Section 13, paragraph 1, line 5, strike out the word "ten" and insert the word "five."

Under the foot notes on page 20 add the following: "For cement grout filler the committee recommends a square edge brick."

Under "Note to Engineers" on page 20, strike out first paragraph of section 1 and second paragraph of section 4.

During the past year the Committee has investigated a number of brick pavements laid on a cement-sand bed and it finds that there is a tendency to adopt this type of construction, owing to the fact that the proper cushion sand can not be obtained in some localities. Where such conditions exist we recommend the cement-sand type of construction. It finds that the mixture of cement-sand now used is one part cement to four parts sand, mixed moderately wet and thoroly rolled. The cement-sand bed is three-quarters inch in thickness after compression.

It also finds that quite a number of highways have been constructed of brick laid on a green concrete base, without protection curbing. Your committee was afforded the opportunity of

seeing a road of this type during construction. It consisted of a concrete base four inches thick, mixed in the proportions of 1:3:6; upon this base was laid a thin layer of dry mortar composed of one part of cement and two parts sand which was screeded with with a movable template.

The brick was immediately placed upon this mortar, then thoroly wetted and rolled with a light hand roller, after which the brick were thoroly grouted. This gave an effective depth of eight inches in thickness.

If it is the wish of the Society this committee will make further study of this type of construction.

E. H. Christ, Chairman.
Henry Maetzel,
F. J. Cellarius,
S. Cameron Corson.

MR. CHRIST: I move the adoption of the report.

The motion was seconded by Mr. Corson, and carried.

MR. TILLSON: Mr. Chairman, it is understood, of course, with such a report as this which has just been made where it recommends certain changes in the present specifications that those changes will be made by the Secretary, and the specifications published in full with the amendments, according to the changes. I will now call for the report on Asphalt Paving by Mr. Smith, Chairman.

MR. SMITH: Mr. President and gentlemen: Your committee on Sheet Asphalt Paving have very carefully considered during the past year the working of the specifications adopted by this society in 1915, and in view of their experience, and as a result of their correspondence during the past year and their conference on Monday last, have decided to recommend the following changes in the existing asphalt specifications:

The first change refers to sand grading and is a paragraph intended to make somewhat more plain the fact that the limits given in the sand grading in the specifications cover the grading desired for pavements for light, medium and heavy traffic, and

that a sand grading which is suitable for a light traffic pavement, is not suitable for a heavy traffic pavement. That point has therefore been emphasized by changing the paragraph on the top of page 6 in Section 7, referring to sand, so that it reads as follows: "The above limits as to mesh composition are intended to provide for such permissible variations as may be rendered necessary by the available sources of supply, and the character of the work to be done, it being understood that the coarser permissible grading is intended for use on light and medium traffic streets only and that for heavy traffic streets, the finer grading shall be required. The mesh composition and character of the sand shall be varied within the limits above specified by the engineer depending upon the kind of asphalt used and the traffic conditions upon the street or streets to be paved."

I might say that your committee has also considered the possibility of calling for separate sand gradings for the three grades of traffic, but in view of the fact that in many localities the available source of supply of sand is somewhat limited, we decided that too narrow a restriction in the grading might exclude in a number of instances the only available sand supply. We have therefore retained the original broad limits and left it to the engineer to narrow them in accordance with the traffic.

In the paragraph under "Filler," page 6, the specifications originally stated, "This shall be thoroly dried limestone dust or dust from equally satisfactory stone or Portland cement." The committee has recommended the elimination of the words "or dust from other equally satisfactory stone," it being our opinion that the weight of practice up to the present is in favor of either limestone dust or Portland cement, and that the phrase, "or other equally satisfactory stone" has led in a number of cases to the use of improper materials for filler, where the engineer in charge of the work was not very deeply posted in asphalt matters.

In paragraph 12, page 8 which covers the laying of the binder mixture we have inserted a clause limiting the amount of compression to be done by tamping, and limiting the speed of the roller in the same way that the laying of the wearing surface

mixture is regulated. This clause comes after the word "rolling," which is in the 19th line from the top of that page and reads as follows: "Tamping shall only be permitted in those places which are inaccessible to a roller. Rolling shall be carried on continuously at the rate of not more than 300 square yards per hour per roller until a compression is obtained which is satisfactory to the engineer."

On page 10, at the end of paragraph 15, which refers to the laying of the wearing surface, we have inserted the following note: "When the pavement is laid alongside of brick or concrete gutters, street car tracks, manhole heads, or liners, it is recommended that the finished surface adjacent to them be left $\frac{1}{4}$ inch high, in order to provide for subsequent compression by traffic and to avoid depressions which would otherwise be liable to occur at these points."

These are all the changes which your committee has decided to recommend for the present year.

REPORT OF SUB-COMMITTEE ON SHEET ASPHALT PAVING SPECIFICATIONS.

Change first paragraph, page six, so as to read:

"The above limits as to mesh composition are intended to provide for such permissible variations as may be rendered necessary by the available sources of supply, and the character of the work to be done, it being understood that the coarser permissible grading is intended for use on light and medium traffic streets only, and that for heavy traffic streets, the finer grading shall be required. The mesh composition and character of the sand shall be varied, within the limits above specified, by the engineer, depending upon the kind of asphalt used and the traffic conditions upon the street or streets to be paved."

Eliminate from second paragraph, page six, the following words:

"Or dust from equally satisfactory stone."

Insert the following in paragraph twelve, page eight, after "rolling" nineteenth line from top of page:

"Tamping shall only be permitted in those places which are inaccessible to a roller. Rolling shall be carried on continuously at the rate of not more than three hundred square yards per hour per roller until a compression is obtained which is satisfactory to the engineer."

Insert the following between the second and third paragraph on page ten.

"Note: When the pavement is laid alongside of brick or concrete gutters, street car tracks, manhole heads, or liners it is recommended that the finished surface adjacent to them be left one-quarter ($\frac{1}{4}$) inch high, in order to provide for subsequent compression by traffic and to avoid depressions which would otherwise be liable to occur at these points."

Francis P. Smith,
R. Keith Compton,
Felix Kleeberg.

I submit the report to you Mr. President, and move its adoption.

MR. SWAN: Mr. President, before a motion to adopt this specification is entertained, I should like to offer a motion that the alternative specifications for asphalt paving herewith submitted, modifying the present standard specifications, be and are hereby adopted as an amendment to the report of the sub-committee on specifications for asphalt paving.

THE PRESIDENT: Are there certain clauses you wish the committee to adopt?

MR. SWAN: I would like to offer this as an amendment and would say that there are no changes as to the physical or chemical requirements, and there is no change in a single test as they appear in the standard specifications of this Society; simply a re-arrangement of them to permit a clear understanding of them both from an engineer's standpoint and a bidder's standpoint. In other words, alternative specifications.

MR. TILLSON: Will the gentleman explain the object of them?

MR. SWAN: It is to allow alternative specifications on the classifying of asphalt.

MR. DOW: What is the object of them? What is the necessity?

MR. SWAN: To get bids for residual and natural asphalt separately.

MR. DOW: Why is that necessary?

MR. SWAN: In what respect?

MR. DOW: Why do you want to do anything like that? Why is such a specification as that necessary? What is the object of it?

MR. SWAN: With your permission Mr. President, I should like to offer a few remarks in defense of this motion and then it will be open for discussion afterwards.

MR. TILLSON: It is to distinguish between the two asphalts. Is that the gist of it?

MR. SWAN: Yes, sir.

MR. TILLSON: Then we would like to hear it, of course.

MR. SWAN: I will read the motion and the specifications. The motion is: That the alternative specifications for asphalt paving herewith submitted, modifying the present standard specifications, be and are hereby adopted as an amendment to the report of the sub-committee on specifications for asphalt paving. The specifications are as follows:

Refined Asphalt and Asphalt Cement.

(4) The refined asphalts to be used for paving mixtures herein required shall be derived in the following manner; separate bids are to be received on the two kinds of asphalt here specified, as provided in suitable proposal blanks:

(A) By heating, if requiring refinement, crude, natural, solid asphalt, to a temperature of not over 400 deg. F., until all the water has been driven off. Crude, natural, solid asphalt shall be construed to mean any natural solid mineral bitumen, either pure or mixed with foreign matter, from which thru natural causes

in the process of time the light oils have been driven off until it has a consistency harder than 100 penetration at 77 degree F. In no case shall such asphalt be prepared at the refinery with any product not hereinafter provided for.

(1) Asphalt cement prepared from refined asphalt, derived as prescribed in (a), shall be prepared either at the paving plant or at the refinery using a flux as prescribed hereinafter. The proper proportion of the refined asphalt and flux shall be melted together at a temperature between 275 and 400 degrees F., and thoroly agitated by suitable appliances until they are completely blended into a homogeneous asphalt cement. When the weight of flux required exceeds 25 per cent of the asphalt cement then asphaltic or semi-asphaltic flux shall be used. Thereafter, the asphalt cement must not be heated to a temperature exceeding 350 deg. F.

If the asphalt cement contains material that will separate by subsidence while it is in a molten condition, it must be thoroly agitated before drawing from storage and while in use in the supply kettles. Excessive agitation with steam or air which will injure the cement must not be used.

The refined asphalt and flux comprising the asphalt cement, shall, when required, be weighed separately in the presence of the authorized inspectors or agents of the engineer.

(2) The asphalt cement shall comply with the following requirements:

(a) It shall be thoroly homogeneous.

(b) It shall have a penetration at 77 deg. F. of 30 to 55 for heavy traffic streets and 55 to 85 for light traffic streets, depending upon the sand and asphalt used and the local climatic conditions.

(c) It shall not flash below 350 deg. F. when tested in a closed oil tester.

(d) When twenty (20) grams of the asphalt cement are heated for five (5) hours at 325 deg. F. in a tin box two and one-quarter ($2\frac{1}{4}$) inches in diameter and three quarters ($\frac{3}{4}$) of an

inch deep, after the manner officially prescribed, the loss shall not exceed five (5) per cent. by weight and the penetration at 77 deg. F. of the residue left after such heating must not be less than one-half the penetration at 77 deg. F. of the original sample before heating.

(e) Ninety-eight and one-half ($98\frac{1}{2}$) per cent. of the total bitumen of the asphalt cement shall be soluble in carbon tetrachloride.

(f) Either the asphalt cement or its pure bitumen when made into a briquette, Dow mold, shall at 50 penetration (77 deg. F.) have a ductility of not less than 30 centimeters at 77 deg. F., the two ends of the briquette to be pulled apart at the uniform rate of 5 centimeters per minute.

When the asphalt cement as used has a penetration other than 50 at 77 deg. F., an increased ductility of 2 centimeters will be required for every five points in penetration above 50 and a corresponding allowance will be made below 50 penetration.

(3) Fluxes: These shall be the residue obtained by the distillation of paraffine, asphaltic or semi-asphaltic petroleums. They shall be of such character that they will combine with the asphalt to be used to form an acceptable and approved asphalt cement complying with the requirements of these specifications. All residuums must pass the following general tests:

(a) They must have a penetration greater than three hundred and fifty (350) with a No. 2 needle at 77 deg. F. under fifty (50) grams weight for one second.

(b) They shall have a specific gravity at 77 deg. F. between 0.92 and 1.02.

(c) When twenty (20) grams of the flux are heated for five (5) hours at 325 deg. F. in a tin box two and one-quarter ($2\frac{1}{4}$) inches in diameter and three-quarters ($\frac{3}{4}$) of an inch deep after the manner officially prescribed, the loss shall not exceed five (5) per cent. by weight and the residue left after such heating shall flow at 77 deg. F.

(d) They shall not flash below 350 deg. F. when tested in a closed oil tester.

(e) They shall be soluble in carbon tetrachloride to the extent of not less than ninety-nine (99) per cent.

(B) By the careful distillation of liquid natural mineral bitumen using such methods of refining as will produce a product complying with the requirements hereinafter given, but shall not be reduced in the refining process to a penetration at 77 deg. F. of less than 30.

(1) Asphalt cement prepared from refined asphalt derived as prescribed in (B) shall be prepared either at the paving plant or at the refinery, using a flux (when flux is required) as prescribed hereinafter.

The proper proportions of the refined asphalt and flux shall be melted together at a temperature between 275 and 400 deg. F., and thoroly agitated by suitable appliances until they are completely blended into a homogeneous asphalt cement. When the weight of flux required exceed 25 per cent. of the asphalt cement then asphaltic or semi-asphaltic flux shall be used. Thereafter, the asphalt cement must not be heated to a temperature exceeding 350 deg. F.

If the asphalt cement contains material that will separate by subsidence while it is in a molten condition, it must be thoroly agitated before drawing from storage and while in use in the supply kettles. Excessive agitation with steam or air which will injure the cement must not be used.

The refined asphalt and flux comprising the asphalt cement shall, when required, be weighed separately in the presence of the authorized inspectors or agents of the engineer.

(2) The asphalt cement shall comply with the following requirements:

(a) It shall be thoroly homogeneous.

(b) It shall have a penetration at 77 deg. F. of 30 to 55 for heavy traffic streets and 55 to 85 for light traffic streets,

depending upon the sand and asphalt used and the local climatic conditions.

(c) It shall not flash below 350 deg. F. when tested in a closed oil tester.

(d) When twenty (20) grams of the asphalt cement are heated for five (5) hours at 325 deg. F. in a tin box and two one-quarter ($2\frac{1}{4}$) inches in diameter and three-quarters ($\frac{3}{4}$) of an inch deep, after the manner officially prescribed, the loss shall not exceed five (5) per cent. by weight and the penetration at 77 deg. F. of the residue left after such heating must not be less than one-half the penetration at 77 deg. F. of the original sample before heating.

(e) Ninety-eight and one-half ($98\frac{1}{2}$) per cent. of the total bitumen of the asphalt cement shall be soluble in carbon tetrachloride.

(f) Either the asphalt cement or its pure bitumen when made into a briquette (Dow mold) shall, at 50 penetration (77 deg. F.), have a ductility of not less than 30 centimeters at 77 deg. F., the two ends of the briquette to be pulled apart at the uniform rate of 5 centimeters per minute.

When the asphalt cement as used has a penetration other than 50 at 77 deg. F., an increased ductility of 2 centimeters will be required for every five points in penetration above 50 and a corresponding allowance will be made below 50 penetration.

(3) Fluxes: These shall be the residue obtained by the distillation of paraffine, asphaltic or semi-asphaltic petroleums. They shall be of such character that they will combine with the asphalt to be used to form an acceptable and approved asphalt cement complying with the requirements of these specifications. All residuums must pass the following general tests:

(a) They must have a penetration greater than three hundred and fifty (350) with a No. 2 needle at 77 deg. F. under fifty (50) grams weight for one second.

(b) They shall have a specific gravity at 77 deg. F. between 0.92 and 1.02.

(c) When twenty (20) grams of the flux are heated for five (5) hours at 325 deg. F. in a tin box two and one-quarter ($2\frac{1}{4}$) inches in diameter and three-quarters ($\frac{3}{4}$) of an inch deep after the manner officially prescribed, the loss shall not exceed five (5) per cent. by weight and the residue left after such heating shall flow at 77 deg. F.

(d) They shall not flash below 350 deg. F. when tested in a closed oil tester.

(e) They shall be soluble in carbon tetrachloride to the extent of not less than ninety-nine (99) per cent.

(5) The preparation and refining of all asphalts admitted under these specifications shall be subject to such inspection at the paving plants and refineries as the engineer may direct. Every asphalt admitted under these specifications, if required by the engineer, shall be equal in quality to the recognized standard for its particular kind or type of asphalt, and information as to its type and source shall be furnished the engineer when requested.

All shipments of asphalt of any one kind shall have the batch number plainly marked on each package or container, and shall be uniform in consistency and composition, and shall not vary from maximum to minimum more than fifteen (15) points in penetration at 77 deg. F.

After a long discussion the motion was lost. Subsequently the vote was reconsidered and defeated by a vote of 59 to 32 on a roll call, the result of which is on file with the Secretary.

MR. TILLSON: I now call for the report on Bituminous Paving Specifications, Linn White, chairman.

MR. WHITE: Your sub-committee on Bituminous Concrete Pavement Specifications did not consider it necessary entirely to re-write the report of last year, which was adopted at the Dayton convention on bituminous concrete, but we have revised that specification in certain particulars, the most important one of which is to substitute for our previous specification on asphaltic cement the specifications which have been recommended and adopted for sheet asphalt pavement, so that the specifications for the two com-

mittees would be uniform in that respect. We believe there is now no reason for any distinction between the character of cements to be used in the two pavements.

In certain other respects your committee has made slight modifications in the specifications as printed and adopted at the Dayton meeting. In the paragraph under "Mineral Aggregate" there was a typographical error in the proceedings as printed; the percentage of bitumen having been omitted it was put in as an addendum and printed in the front of the proceedings. We now introduce it in the title referring to grading, "Bitumen, 7 to 9 per cent." In the paragraph under "Mineral Aggregate" just preceding the table of percentages just referred to, there is a discrepancy. The former specification requires the dust entering into the mix in no case to show over 11 per cent. passing a 200-mesh screen. Our standard grading calls for 7 to 10 per cent. We therefore correct the figures 11 to read 10.

In the second paragraph following the paragraph referring to grading, which is still under the general heading of "Mineral Aggregate" we rewrite the last paragraph, wherein it says that dust includes fine sand passing a 200-mesh screen, not exceeding 5 per cent. of the total mixture, so that it will be a little clearer as to meaning. The paragraph would then read as follows: "The item designated as dust includes, in addition to the stone dust or Portland cement that may be added, such fine sand passing a 200-mesh screen as may be found self-contained in the sand to be used, and such 200-mesh mineral as may be self-contained in the refined asphalt, but the sand as used in the mixture shall not contain over 5 per cent. passing a 200-mesh screen."

In the paragraph pertaining to method of mixing, near the latter end of it, the old specification stated that the proportions of asphaltic cement, etc., shall be added to the hot aggregate and immediately mixed in a properly designed mixer with revolving blades. We propose to cut out the words "with revolving blades" and say, "in a properly designed revolving mixer," recognizing the fact that asphalt concrete has been successfully made with other kinds of mixers.

In other respects our specifications on bituminous concrete as reported to the Dayton meeting, stand the same for this year.

The report of the committee as filed with the Secretary, but not read to the Convention, consists of a copy of the separate edition of the specifications as adopted in 1915 with changes which are described below and omitting all of the specifications for bitulithic paving on page eleven and the pages following it. It is signed by Linn White, chairman, W. H. Connell and Isaac Van Trump.

REVISIONS OF SPECIFICATIONS FOR ASPHALTIC CON-
CRETE PAVING, EDITION OF 1915 AS
ADOPTED IN 1916.

P. 1. Under title "*Sub-Drainage*," second paragraph, first line, omit "open"; second line insert "or" after word "material."

P. 3. Under title "*New Macadam Foundation*," third paragraph p. 3, second line, change "flush" to "flushed;" fourth line, insert "third" before "layer;" fifth line, change "shall" to "should;" sixth line, change "one and one-half ($1\frac{1}{2}$) inches" to "one (1) inch after rolling;" eleventh line, change "the" to "sufficient;" twelfth line, insert "entirely" after "voids."

P. 4. Under same title, fifth and sixth lines p. 4, change "four and one-half ($4\frac{1}{2}$)" to "five (5)."

P. 6. Under the title "*Mineral Aggregate*," second line p. 6, change "twenty" to "ten (10);" third line, add "nor over five (5) per cent. passing the 200-mesh screen." Second paragraph, first line, take out "lime" from "limestone;" fourth line, change "eleven (11)" to "ten (10)." Third paragraph, insert at top of table line "Bitumen, 7-9 per cent." Fourth paragraph, change position of "only" to read "shall be used only in." Substitute for the fifth paragraph the following: "The item designated as dust includes in addition to the stone dust or portland cement that may be added, such fine sand passing a 200-mesh screen as may be found self-contained in the sand to be used, and such 200-mesh material as may be self-contained in the refined asphalt."

P. 7. Fourth line, insert "revolving" before "mixer" and omit "with revolving blades."

Pp. 8, 9. Omit all under headings "*Asphaltic Cement*" and "*Flux*" and insert instead "Use the specifications for asphalt, as-

phalt cement and flux reported by the sub-committee on Sheet Asphalt Paving and adopted by the Society."

MR. SMITH: I move the adoption of the report.

The motion was seconded by Mr. Kingsley and carried.

MR. TILLSON: The next report I will call for is the one on Concrete Paving, by Mr. Hardee, Chairman.

MR. HARDEE: Mr. Chairman and Gentlemen: Your Committee on Concrete Pavement desires to submit this report, with the statement that the outline of the report was submitted to the general committee on specifications, and as I understand, approved. The changes that are suggested are very few, and as the report is rather a lengthy one, we might save time if I would merely read by reference to the report that was adopted at Dayton, which you can readily follow if you have copies, or I might explain them. I will mention these changes by reference to the Dayton committee report.

The committee thought it advisable on Page 390, paragraph 2, in order to make the title under the caption of "Aggregate" a little clearer at a glance, to add, in parenthesis, the word "sand." That is the definition of the fine aggregate, which, in effect, is really sand.

On page 391, line 3, we have put in between the word "the" and the word "report" "prevailing." That line refers to specifications adopted by the American Society for Testing Materials, and we thought it would be well to put in the word "prevailing," so as to indicate clearly that what was intended would be the specifications of the American Society for Testing Materials at the time.

On page 391, we have struck out in the last paragraph the words "coefficient of wear," for the reason that the members of the committee, growing out of their experience with various aggregates, have found that in some localities the proportion of wear of very hard stones would amount to as much as 12 pounds, whereas the general run of stone thruout the country would not run more than from 4 to 8. They thought it advisable to eliminate that particular paragraph from the specifications, leaving to the local engi-

neer to fix whatever coefficient of wear would be most applicable to the stone he was going to use.

The other two changes are in paragraphs 5 and 6, which refer to the mortar mix, fixing what we believe to be a more definite proportion of cement to the amount of sand used, and also fixing more definitely what we believe would be a proper proportion of mortar to the mineral aggregate. Instead of fixing arbitrarily, as the Dayton specifications had, a certain prescribed mix, we propose the specification as follows: "Voids in the fine aggregate shall be determined by saturation, and not less than 20 per cent. more cement shall be employed than the volumes of voids thus determined. In no case shall the proportion of cement to fine aggregate be leaner than 1 to 2. (6) The voids in the coarse aggregate shall be determined by saturation, and not less than 20 per cent. more mortar shall be employed than the volume of voids thus determined."

That is carried thru, the same amendment, into the two-course pavement. What I have read has reference to one-course pavement.

Those are the only provisions that the committee, Mr. Chairman, has to suggest for adoption.

The full report of the committee on file with the Secretary, but not read to the Convention consists of the specifications published by the Society as adopted in 1915 with the following changes:

P. 1. Section 2, insert "(Sand)" after "2. Fine Aggregate." Second paragraph of Section 2, tenth line, insert "prevailing" before "Report." Section 3, second line, for "gravel" substitute "pebbles." Omit foot note.

P. 2. Omit last paragraph of Section 3 on coefficient of wear. For Section 5 substitute the following: "5. Voids in the fine aggregate shall be determined by saturation and not less than twenty (20) per cent. more cement shall be employed than the volume of voids thus determined; in no case shall the proportions of cement and fine aggregate be leaner than one (1) to two (2)." For Section 6 substitute the following: "6. The voids in the coarse aggregate shall be determined by saturation and not less than twenty

(20) per cent. more mortar shall be employed than the volume of voids thus determined." For Section 7 substitute the following: "7. Water shall be clean, free from oil, acid, alkali, vegetable matter and other deleterious substances." Omit foot note.

P. 3. Section 8, second paragraph, third line, omit "nor more than ten (10)."

P. 4. Section 17, third and fourth lines, change "wet" to "wetted" and omit "but shall show no pools of water when the concrete is placed."

P. 6. Foot note, second line, insert after "specifications," "for one-course and two-course pavements;" fourth line, change "under the" to "dependent upon." Then transfer foot note to position above heading "TWO COURSE PAVEMENT" and make it Section 21. Omit * in heading. Change Section 1 to read: "1. Cement.—Same as for Section 1, one-course pavement." Change Section 2 to read: "2. Fine Aggregate.—Same as Section 2, one-course pavement."

P. 7. Change Section 3 to read: "3. Coarse Aggregate.—Same as Section 3, one-course pavement." Insert in sub-head No. 1, "Coarse" before "Aggregate." Insert in sub-head No. 2, "Coarse" before "Aggregate." Omit foot note.

P. 8. Change Section 5 to read as follows: "5. Base.—The voids in the fine aggregate shall be determined by saturation and not less than ten (10) per cent. more cement shall be employed than the volume of voids thus determined; in no case shall the proportions of the cement and fine aggregate be leaner than one (1) to two and one-half (2½).

"The voids in the coarse aggregate shall be determined by saturation and not less than twenty (20) per cent. more mortar shall be employed than the volume of voids thus determined." Change Section 6 to read as follows: "6. Wearing Surface.—The coarse aggregate in the wearing surface shall be No. 1 or No. 2 as specified above. The voids in the fine aggregate shall be determined by saturation and not less than twenty (20) per cent. more cement shall be employed than the volume of voids thus determined; in no case shall the proportion of cement to fine aggregate be leaner than one (1) to two (2).

"The voids in the coarse aggregate shall be determined by saturation and not less than twenty (20) per cent. more mortar shall be employed than the volume of voids thus determined." Change Section 7 to read: "Section 7 shall be the same as Section 7 for one-course pavement."

P. 9. For Sections 8 and 9 substitute "Sections 8 and 9 shall be the same as Sections 8 and 9 for one-course pavement."

Pp. 9, 10. For Sections 10 to 16 inclusive substitute "Sections 10 to 16 inclusive shall be the same as Sections 10 to 16 inclusive for one-course pavement."

P. 10. Section 18, third and fourth lines, change "wet" to "wetted" and omit "but shall show no pools of water when the concrete is placed."

The report is signed by W. J. Hardee, Chairman; K. C. Gaynor, William A. Hansell, Jr., C. E. P. Babcock, Manley Osgood, and G. C. Cummin.

MR. HARDEE: I move the adoption of the report.

The motion was seconded by Mr. Blanchard, and carried.

MR. TILLSON: I now ask for the Committee on Stone Paving to make its report, Mr. Schmidt, Chairman.

MR. SCHMIDT: Mr. Chairman, there have been practically no changes made in the stone block specifications, so far as the stone blocks themselves are concerned. The use of gravel between the blocks where bituminous filler is used has been eliminated.

REPORT OF THE SUB-COMMITTEE ON SPECIFICATIONS FOR STONE BLOCK PAVEMENTS.

Your sub-committee on stone block pavements were in session on this date (October 9), from 11 a. m. to 1 p. m. and from 2:30 p. m. to 7 p. m. The following members of the sub-committee were present:

H. H. Schmidt, Chairman, Brooklyn, N. Y.

J. E. Ramsay, Salisbury, N. C.

C. D. Pollock, New York City.

G. A. Carpenter, Pawtucket, R. I.

R. A. McGregor, New York City.

Informal hearings were given to representatives of the various manufacturers, and a number of members of the Society were also present during the sessions.

The revised specifications approved by the sub-committee are presented herewith. No changes have been made in the specifications for the stone blocks themselves, but the use of gravel in the joints between the blocks where bituminous filler is used, has been eliminated. A joint filler consisting of a mixture of sand with either tar pitch or asphalt cement has been specified. The sub-committee, in last year's report to your committee, recommended the trial of such a joint filler and last year the sub-committee considered the advisability of specifying this joint filler, but at that time it was thought that its use was not general enough to warrant its adoption by the Society. During the past year, however, the use of such a joint filler has become so general that the sub-committee believes it should be adopted as a standard joint filler by the Society. The specifications for the tar pitch and the asphalt cement have been modified to meet this change.

The specification for cement grout filler is substantially the same as in the previous specification, but the wording and arrangement have been simplified. The only important change is a requirement for machine-mixed grout only.

While the sub-committee has recommended a range in the melting point for the tar pitch of 115 to 135 degrees Fahrenheit, attention is called to the necessity for selecting a melting point within these limits to suit varying climatic conditions and gradients. A variation of 5 degrees Fahrenheit either way from the temperature selected should be permitted by the Engineer.

The sub-committee calls attention to the fact that the Society has taken no steps to standardize the specifications for stone curb. Almost every city in the country uses stone curb to some extent, and the specifications used by the various cities differ so widely that the stone quarries are unable to prepare very much curbstone in advance. A saving would, no doubt, be effected if the stone curb specification were standardized and the sub-committee, there-

fore, recommends that the Society either appoint a special committee on stone curb or authorize the Stone Block Committee to present at the 1917 meeting of the Society a standard specification for stone curb.

H. H. Schmidt, Chairman.
R. A. MacGregor.
J. E. Ramsey.
George A. Carpenter.
C. D. Pollock.

The specifications accompanying the report, but not read to the Convention are those published by the Society as adopted in 1915 with the following modifications:

P. 3. Insert after Section 9 a new heading "RAMMING" and the following: "10. After the blocks are laid, they shall be rammed to a solid bearing, the joints shall be adjusted, all unsatisfactory blocks shall be taken out with tongs and all low blocks shall be raised to an even and true surface. Pinch bars shall not be used except by special permission of the engineer and no sand shall be placed in the joint except when mixed with the bituminous filler specified hereafter.

P. 3. Section 10, change "10" to "11." In second line omit "Gas."

P. 3. Heading A, omit "GAS."

P. 3. Instead of the first paragraphs of Section 11 insert the following: "12. The joint filler used shall be the paving pitch hereafter described, thoroly mixed with as much hot dry sand as the pitch will carry, but in no case shall the volume of the sand exceed the volume of the pitch. The sand shall be fine and clean and all of it shall pass a 20-mesh screen. It shall be heated to a temperature of not less than 300 deg. F., nor more than 400 deg. F., and shall be between these limits when mixed with the paving pitch.

"The paving pitch shall be heated in kettles properly equipped with an approved thermometer, which shall register the temperature of the pitch.

"The mixture shall be flushed on the surface of the blocks and pushed into the joints with suitable tools, re-flushing or re-pouring, if necessary, until the joints remain permanently filled flush with the surface of the pavement. As little as possible of the mixture shall be left on the surface."

P. 4. Omit the first three paragraphs. In the fourth paragraph, omit "gas—." In the sixth paragraph change "110 and 125" to "115 and 135." In the eleventh paragraph omit "gas" and "filler." In the twelfth paragraph omit the last sentence. In the thirteenth paragraph omit "gravel and."

P. 5. Instead of Section 12 insert the following: "13. The joint filler used shall be the asphalt cement hereafter described, thoroly mixed with as much hot, dry sand as the cement will carry, but in no case shall the volume of the sand exceed the volume of the cement. The sand shall be fine and clean and all of it shall pass a 20-mesh screen. It shall be heated to a temperature of not less than 300 deg. F., nor more than 400 deg. F., and shall be between these limits when mixed with the cement.

"The asphalt cement shall be heated in kettles properly equipped with an approved thermometer, which shall register the temperature of the cement.

"The mixture shall be flushed on the surface of the blocks and pushed into the joints with suitable tools, reflushing, or re-pouring, if necessary, so that the joints remain permanently filled flush with the surface of the pavement. As little as possible of the mixture shall be left on the surface.

"The asphalt paving cement shall be obtained by the distillation of an asphaltic petroleum at a temperature not exceeding 700 deg. F., and shall comply with the following requirements:

"(a) It shall be homogeneous.

"(b) Melting point shall not be less than 130 deg. F., nor more than 145 deg. F.

"(c) Solubility in carbon tetrachloride shall not be less than ninety-eight and one-half (98½) per cent.

"(d) Penetration at 77 deg. F., shall not be less than 60 nor

more than 100, the penetration test being made with a No. 2 needle for five (5) seconds under a load of 100 grams, and the penetration at 100 deg. F., shall not exceed three (3) times its penetration at 77 deg. F., the conditions of time and load being as above established. The contractors before beginning work shall obtain from the engineer a statement in writing as to the penetration desired for any particular contract, and a variation of not greater than ten (10) points either way from this penetration will be permitted.

“(e) Ductility at 77 deg. F., shall not be less than 40 centimeters, the rate of elongation being five (5) centimeters per minute.

“(f) It shall not lose more than three (3) per cent. by volatilization when maintained at a temperature of 325 deg. F., for five (5) hours, nor shall the penetration of the residue after such heating be less than one-half the original penetration.

“The asphalt filler shall be used on the work at a temperature of not less than 275 deg. F., and shall at no time be heated above 350 deg. F.

“It shall be delivered where directed by the engineer in time to allow for examination and analysis.”

P. 6. Omit first five paragraphs. In the sixth paragraph, first line, omit “gravel and.” Omit Section 14. In Section 15, third line, insert “or scraped” after “broomed.” In the fourth line insert “repeated” in place of “continued.” In the fifth line insert “and before the initial set has taken place” after “settles.”

P. 7. Second paragraph, third line, insert “only enough” in place of sufficient. Change fourth line to read “added to make a grout which will flow to the bottom of the joints.” Third paragraph, change first sentence to read, “The grout shall be machine mixed in a batch mixer approved by the engineer and shall be applied to the joints before the ingredients have separated.” Omit last two sentences. Omit last three paragraphs and insert following: “After the grouting is completed and a sufficient time for hardening has elapsed so that a coating of sand will not absorb moisture from the cement mixture, one-half ($\frac{1}{2}$) inch of sand shall be spread over the whole surface and shall be kept damp until the street is opened for traffic.”

P. 8. First paragraph, omit last sentence. Second paragraph, omit after "accepted," second line to "such," third line.

MR. SCHMIDT: I move the adoption of the report.

The motion was seconded by Mr. Smith and carried.

MR. SIERRERD: In that connection I would move that the question of specifications for stone curbing be referred to the same committee.

The motion was seconded by Mr. Smith and carried.

Upon explanation by Linn White, chairman of the sub-committee upon Bituminous Paving Specifications, that his report, described by him on page 655, but not read to the Convention, was intended to cover only one specification for bituminous concrete and not to report a specification including bitulithic pavement, a discussion arose, in the course of which the vote adopting the report was reconsidered.

After a statement from George W. Tillson, chairman of the general committee on Standard Specifications, that the report of the sub-committee was approved by the general committee as regarded the changes in the specifications for bituminous concrete pavement, and that the omission of any mention of the specifications for bitulithic pavement left the specifications for bitulithic pavement standing as they were, without change, and a ruling by the President that as the specification for bitulithic pavement was passed by the Convention last year and as the report submitted by Mr. White mentioned only bituminous concrete, the bitulithic specification consequently stands and the report will not affect it in any way, the report of the committee was again adopted.

Mr. White then made a motion to eliminate the bitulithic specification from the standard specifications for 1916. The motion was seconded by Mr. Connell. Mr. Hardee moved that the matter be laid on the table, which motion was seconded and carried by a standing vote of 47 to 34.

After the discussion and defeat of the motion to reconsider the vote on the adoption of the report of the sub-committee on Asphalt Paving Specifications, as stated on page 655, the Convention adjourned to meet at 9 a. m. Friday.

FRIDAY, OCTOBER 13, 1916.

MORNING SESSION.

The meeting called to order at 9 a. m.

THE PRESIDENT: I would ask Mr. Dutton to read the report on wood block paving.

Mr. Dutton read the report as follows:

REPORT OF THE SUB-COMMITTEE ON WOOD BLOCK
PAVING SPECIFICATIONS.

Your sub-committee on wood block paving specifications respectfully submits its report of the work done during the year since your last meeting. At that meeting there was a motion adopted:

"Directing the Secretary to print in the proceedings, a request that members submit to the chairman of the several sub-committees, any matter which they wish to bring to the attention of the committee, at least ten days before the time of holding the convention." (1915 Proceedings. Pages 536-7.)

In compliance with such request, Mr. P. C. Reilly, submitted a specification (1915 Proceedings, page 466); Mr. W. H. Fulweiler, chemist of the United Gas Improvement Company, submitted a specification (1915 Proceedings, page 467); Mr. C. N. Forrest, chemist of the Barber Asphalt Paving Company, submitted a specification (1915 Proceedings, pages 467-8-9); and J. W. Howard, consulting engineer on roads and pavements (1915 Proceedings, page 469). During the year no further specifications were submitted to the committee, except that Mr. C. N. Forrest mailed to the chairman a specification similar to the one published as above.

These specifications, together with the one submitted to the Society and printed as information, have been before the members for the past year, and no comment pro or con, has been expressed, so that as far as the committee is concerned we know nothing further as to the opinions of the members of the Society than we did a year ago, but the creosoting and use of wood blocks has been going on, notwithstanding no specifications have been adopted by the Society.

There were some correspondence and conferences of the committee on the advisability of a joint meeting of the creosoted wood block committees of the various societies dealing with such matters, but no agreement was arrived at, but we thought that such a meeting would be of great benefit.

At the request of your chairman of the committee on standard specifications, Mr. George W. Tillson, such a meeting was called to be held in Brooklyn, N. Y., on September 12, 1916.

There were present at this meeting two members representing the American Society of Civil Engineers; four representing the American Society of Municipal Improvements; one representing the American Railway Engineering Association; one representing the Southern Pine Association, seven representing the American Wood Preservers' Association, and five representing the American Society for Testing Materials.

This was the most important meeting ever held affecting the creosoted wood block interests. All matters pertaining to the wood block industry were fully discussed at this meeting, and the most vital parts of the specifications as herewith submitted, viz: the oil and treatment, were unanimously adopted by this general conference. The matter of the use of other oils than the ones submitted was gone over thoroly, and it was the consensus of opinion that we were not ready to submit for adoption a specification permitting the use of water gas tar wholly or in part, without more data and investigation of its qualities as a preservative. The members were, however, willing and ready to follow up and investigate all authoritative cases where water-gas tar had been used and see if the results were as claimed; but from all the information at hand we did not consider it wise to recommend a water-gas tar specification.

Especially to be emphasized is the fact that a strong committee of the American Wood Preservers' Association is now at work compiling data and a full report to be submitted to their association in January. This report will doubtless form the basis for a report to this Society next year.

In regard to the specification for coal-tar oils herewith presented for adoption; it is almost the same as the one presented to the Society at its last meeting in Dayton, Ohio.

The material points of difference are:

1. The oil specification has been divided and a separate clause provided for a mixed coal tar and creosote oil, called "Coal Tar Paving Oil"—and a straight distillate oil called "Coal Tar Distillate Oil."

2. The "treatment" clause has been more minutely defined and the different processes in the treatment limited so that a better block will be the result. Not only a better block, but one which will give better results in the pavement, and which will eliminate most of the troubles which are charged against the wood block pavement.

The amount of oil to be used has been limited to sixteen pounds per cubic foot; which is also along the right lines to reduce bleeding.

Ellis R. Dutton, Chairman.

A. W. Dow.

Hermann von Schrenk.

The specifications accompanying this report will be found on page 588.

MR. DUTTON: I move the adoption of the report and specifications.

The motion was seconded by Mr. Blanchard.

MR. HOWARD: Inasmuch as we have papers on the subject of wood block pavement prepared during the past year for presentation here by Mr. Teesdale and Mr. Reilly, and we are going to discuss new wood block pavement specifications, it is always the intention of the Society to hear all the information before we take up the specifications. It would be wise here today to have Mr. Teesdale and Mr. Reilly read these papers before we take up the new specifications. I move that Mr. Teesdale and Mr. Reilly first present their papers.

THE PRESIDENT: There is a motion before the house.

MR. HOWARD: I move this as a substitute motion.

Motion seconded by Mr. Brown.

MR. HOWARD: The question is, shall we hear these papers before we consider the new specifications. It is important we should, because at the 1914 and 1915 conventions of this Society it has practically refused to adopt substantially closed or exclusive specifications for preservative oil for use in wood blocks, and because a full discussion should certainly take place on the new wood pavement specifications presented by the committee composed of Messrs. Tillson, Sherrerd and others. I say this because I have carefully studied the proposed specifications and find much in doubt. The tests for preservatives, I am creditably informed by several chemists and a telegram from Chicago, may have been practically prepared by a chemist of a large corporation which I believe almost, if not wholly, controls the first preservative named in those specifications, "coal-tar paving oil," and perhaps may influence to a large degree materials which are necessary to manufacture the second one named, "coal-tar-distillate oil." The specifications we have to consider state in a note that refined water-gas tar can be used by those who wish it.

Those specifications contain new and untried tests for preservatives. I mean certain "float" and "gravity of fractional distillates" tests, and at temperatures never before used. Therefore it is impossible to continue to use the many valuable records in standard books such as by Lunge and the United States Government and municipal records of tests by old and recognized methods of many long-used and successful creosote oils, and compare these suggested new tests with them or know by these new tests whether they are descriptive of special products or standard tests of qualities which all good wood preservatives must have. I prefer to have this demonstrated or to myself make a series of comparative tests by the old standard methods and the new proposed ones, before I give my unqualified approval of the new specifications from the committee. I hope our Society will recommend that both types of preservatives in those specifications will be used, and award contracts to the lowest responsible bidder without respect to which type of oil is used. I personally regard a high grade distillate creosote oil as superior to a preservative containing hard pitch, as stated on page 241 of the 1915 Proceedings of this Society.

Permit me to further call your attention to the fact that the

new specifications on leaving the committee wrongly forbid a city engineer to fully test the quantity and quality of the oil in his blocks after the blocks have been received in his city, but confine that to previous inspection by others at a distant plant. A high city official must retain the right to inspect and test all his materials at any time, even the day they are being put into a public work, so as to assure himself honest, good and efficient qualities.

MR. FISHER: Before that motion is put, I would like to say a word on it. I dislike to be opposed to anything that my friend Howard brings up, as he is generally right, but I think this is wrong. I think we decided last night to take up this matter ahead of these papers. According to the report made by the chairman of this committee this matter has been up before the chemists of these different associations. I think we should go on with the program.

The substitute motion of Mr. Howard was then put by the chair, and lost.

The original motion to adopt the report of the committee was then put by the chair, and carried.

MR. BLANCHARD: Mr. President, I move the passage of the following motion: That a committee of five, consisting of George W. Tillson as chairman, and four active members to be selected by him, present on the first day of the 1917 Annual Meeting a revised Constitution and By-Laws of this Society and that the committee forward its report to the Secretary six weeks prior to the 1917 Annual Meeting and that the report be forwarded to all members of the Society one month prior to the 1917 Annual Meeting.

After some discussion the motion of Mr. Blanchard in its revised form as above stated was seconded by Mr. Hubbard and carried.

THE SECRETARY: I have a motion, which if I may be permitted, I will present at this time. It was left by Mr. Lyman, the city engineer of Louisville, who wished me to present it for him. I move that the Committee on Street Paving be instructed to investigate the various methods of street railway track construction in paved streets and report with recommendations at the 1917 meeting.

The motion was seconded by Mr. Goldstein, and carried.

THE PRESIDENT: We will now have Mr. Reilly's paper on "The Proper Oil for Treating Creosoted Wood Blocks for Paving."

Mr. Reilly's paper will be found on page 56.

THE PRESIDENT: Mr. Teesdale's paper is in the advance papers and we will take that as read by title.

Mr. Teesdale's paper will be found on page 79.

Now, these papers are open for discussion.

If there is no discussion, we have with us today Mr. Preston S. Millar, of New York City, who will present his paper on "Recent Developments in Street Lighting Theory and Practice."

Mr. Millar's paper will be found on page 185.

THE PRESIDENT: Now, we are coming towards the close of our program. There is but one other paper that will be read, and that is on "Concrete Paving Experiences," by K. C. Gaynor, of Sioux City, Iowa. The paper on "Vertical Fiber Brick and Wood Block Pavements," by E. A. Kingsley, will be read by title. "Granite Pavements in the Boro of Manhattan," by R. A. MacGregor, of New York City, will be read by title, and the "The Repaving of Broad Street, Elizabeth, New Jersey, with Grouted Granite Block," by Thomas E. Collins, City Engineer, is in the advance papers, and will be read by title. "Attention to Detail, a Weak Point in American Municipal Work," by Mr. Durham, of Hackensack, N.J., will also be read by title. The only other report is the report of Committee on Standard Forms, by Mr. Folwell. The remaining papers on "New Street Lighting System being Installed in Milwaukee, Wisconsin," by Arthur J. Sweet, and the report of the Committee on Fire Prevention by Mr. Chausse, of Montreal, "Uniform Boiler Laws," by John C. McCabe, of Detroit, and "My Experiences with Cost Data on Municipal Works," by Paul E. Mercier, of Montreal, will be read by title.

Before, however, calling for the two to be read, it is now the time for the incoming President to take the chair. We have had a very good meeting here. We have had a strenuous meeting on one or two occasions, and it is a good thing for this Society to have

them, for a society or body which is dead never has any strenuous times; everything goes along, cut and dried, and the uses and possibilities of the Society are limited. So that I think we have had a good convention in that way, where the discussions have been very much to the point, and I am glad to say, more or less agitated. I hope that the coming conventions will be even better than this, and you will have as a chairman Mr. Norman S. Sprague, of Pittsburgh, who, most of you know, is quite an orator and a first-class engineer of experience and broad mindedness. I therefore take pleasure in calling on Mr. Norman S. Sprague to succeed me as chairman and President of this Convention.

PRESIDENT-ELECT SPRAGUE: Mr. President and Gentlemen of the Convention: In accepting the Presidency of this Society, I have a keen realization of the honor conferred and a most profound sense of the confidence which the Society has reposed in me by election to this high office. In the deliberations of the Society and in the administration of its affairs it will be my very pleasant duty to render the best service of which I am capable. The past Presidents of this Society have set a high standard of efficiency and if I can terminate my term of office with the same degree of credit and success as our retiring President, Mr. Macallum, I shall indeed be satisfied. I thank you, gentlemen.

MR. HOWARD: Mr. President, I move that this Society thank the retiring President, Mr. Macallum, for the conscientious, efficient and satisfactory services he has rendered us as President.

The motion was seconded by various members, and adopted by unanimous rising vote.

MR. MACALLUM: I thank you, gentlemen, for the expression of opinion which you have given to me. I have had a great deal of pleasure out of this meeting, especially the one last night, which got rather agitated. I have enough fighting blood in me to appreciate a good scrap, and, as I said before, if the meeting had been quiet, with no discussions, and everything just going along without any agitation, then the Society, I think, would be getting dead. The very fact that it has these agitations, and that everybody is not of one opinion and not backward in expressing opinion, shows, I think, that we are a live Society, and that we are appreciated beyond our own dominion. I thank you.

PRESIDENT SPRAGUE: The next order of business on the program is a paper by K. C. Gaynor, consulting engineer, of Sioux City, Iowa, on "Concrete Paving Experiences."

Mr. Gaynor's paper and part of the discussion will be found on page 53. The following was returned too late to be printed immediately following the paper:

MR. LAMB: I have just finished a reinforced concrete road for the State of Connecticut, a part of the Boston Post Road leading thru Stratford. The surface was finished by scoring it with a rattan broom before the concrete had set. An ordinary rattan broom was used, but the number of rattan bristles was reduced by cutting the broom in half lengthwise. This brooming has the effect of destroying the smoothness of the surface and of exposing the stone. Troweling the surface buries the stone and makes a brittle sand and cement layer on top, which the brooming overcomes.

We used two thicknesses of tarred paper at the contraction joints instead of the usual expansion joints of asphalt. As the joints are chiefly to provide for contraction I consider the use of the tarred paper good practice. These contraction joints should be made strictly vertical, as beveled joints crack under traffic.

MR. TALBOT: I wish to say a word on this matter of smoothness of surface. In West Virginia conditions are possibly worse than elsewhere because of the fact that in the mountains the roads were not as carefully laid out as in other states and we therefore have many heavy grades. On the Buffalo road in the Mannington district in Marion County, part of the road was corrugated and part was not. Various persons have broomed the surface feeling that that made it a little rougher, but my experience goes to show that the brooming is not advantageous and in fact is unnecessary. The concrete road is a stone road held together with a cement sand binder, the stones taking the wear, and, the binding wearing slightly faster than the stone, the surface remains continuously rough and there is no slipping.

A MEMBER: I would like to state my experience with concrete roads. The gentleman has just spoken with reference to the cement filler wearing away from around the stone. We have concrete roads made of limestone, trap rock and granite. One in particular is

the approach to a bridge on a 5 per cent. grade. It has now been in use three years and is so slippery that we have used a coal-tar product to cover it, and that must be done at intervals of two or three times a year. The tar is covered by granite or trap rock chips.

We have another street which we have recently had covered under a specification of a half gallon to a square yard and trap rock chips. That street in places has been covered for about two months and there are places on a 7 per cent. grade which are entirely scraped off back to the old surface of the street. It was originally laid six years ago.

Another approach to another bridge had been given corrugations about three inches apart. The traffic has worn the pavement smooth.

I did not catch enough of the speaker's paper to learn whether be used longitudinal expansion joints or not. It seems to me that, on bridge approaches especially, not only longitudinal but transverse expansion joints should be used. Two cracks on that 200 feet of bridge approach have been cut out and filled with expansion joint material and there has been no further cracking.

PRESIDENT SPRAGUE: I want to say that I was somewhat surprised about laying a concrete pavement on a 16 per cent. grade. The city of Pittsburg, I presume has as steep grades as any city in the country, and I was recently confronted with the question of a proper type of pavement for a 21 per cent. grade, and I finally solved the problem by using block stone, and having the stone project one above the other.

If there is no further discussion on this paper, we will now have a paper by Mr. C. D. Pollock, consulting engineer, New York, on "Maintenance and Its Importance in Selecting Pavements."

Mr. Pollock's paper and the discussion will be found on page 124.

THE PRESIDENT: The next is the report of the committee on Standard Forms, A. Prescott Folwell, Chairman.

Mr. Folwell read the report which, with the discussion will be found on page 562.

PRESIDENT SPRAGUE: Mr. Folwell, do you move the adoption of this report?

MR. FOLWELL: I move the adoption of this report, yes, sir.

The motion was seconded, and carried.

MR. FOLWELL: I might say if any member has not received our standard units, I have them in envelopes here, and after the meeting anybody who wishes can obtain copies.

MR. CHRIST: Mr. Folwell has asked the Society to give them authority to do certain work along the line of the promotion of uniform units. I would like to have Mr. Folwell put that resolution in form himself.

PRESIDENT SPRAGUE: The chair will entertain a motion from Mr. Folwell for that purpose.

MR. FOLWELL: The motion perhaps might be as it was last year, that the Committee on Standard Units be continued for the following year, and be directed by the Society to carry on the work of publicity on these units with a view of securing their general adoption, and be authorized to use the funds of the Society for that purpose.

The motion was seconded and carried.

PRESIDENT SPRAGUE: We will now have the report of the committee on resolutions. Mr. Reimer will read the report.

MR. REIMER: In the absence of Mr. White, the chairman of this committee, I will read the report, which is as follows:

RESOLVED: That the American Society of Municipal Improvements, in Convention assembled, do hereby express its deep feeling of appreciation of the courtesies extended to it by the local committee of arrangements, the City Government of Newark, as exercised thru the Mayor, the City Council and the Board of Works, by the authorities of the County of Essex and for courtesies of individual citizens, to the Public Service Corporation for transportation furnished and to the ladies' committee for the bounteous entertainment furnished to the visiting ladies.

A. P. Folwell.

R. K. Compton.

G. H. Norton.

F. A. Reimer.

Linn White, Chairman.

MR. REIMER: I move the adoption of the report.

MR. DENMAN: I would respectfully move an amendment to include a recognition of the authorities of the County of Essex, who have also contributed very materially to the success of this entertainment, through Mr. Reimer. His modesty probably occasioned this omission. (*The amendment is included in the resolution as printed above.*)

The amendment was duly seconded and carried, after which the original motion, as amended, was put by the chair and adopted.

THE PRESIDENT: If there is no further business to come before this Convention, I will declare an adjournment, to meet in New Orleans in 1917, and we hope we will see you all there.

ATTENDANCE AT CONVENTION. NEWARK, NEW JERSEY.

Carl A. Adam, Los Angeles, Cal.
J. L. Adams, Jr., Newark, N. J.
H. F. Ahrens, Jr., Leonia, N. J.
John Aikman, Newark, N. J.
James W. Alden, Newark, N. J.
J. Bruce Aldrich, Baltimore, Md.
Henry C. Allen, Syracuse, N. Y.
Kenneth Allen, New York City
Horace Andrews, Albany, N. Y.
Alexander Archibald, Newark, N. J.
Mrs. Alexander Archibald, Newark,
N. J.
Joshua Atwood, Boston, Mass.
Mrs. Joshua Atwood, Boston, Mass.

Col. C. E. P. Babcock, Buffalo, N. Y.
C. W. Baker, Newark, N. J.
M. N. Baker, New York City
J. A. Ballinger, Jacksonville, Fla.
Charles H. Barrett, Gloucester, Mass.
R. R. Barrett, New York City
Geo. C. Bartram, Newark, N. J.
W. B. Bartholomew, Allentown, Pa.
Albert Bastis, Minneapolis, Minn.
M. W. Bath, New York City
Carl Baumwart, Newark, N. J.
C. W. Bayliss, Philadelphia, Pa.
C. H. Beacham, Easton, Pa.
J. L. Beggs, Kansas City, Kans.
E. de Bellefeuille, Point Claire, Can.
J. J. Berry, Newark, N. J.
E. B. Besseliere, New York City.
Mrs. E. B. Besseliere, Bayonne, N. J.
A. H. Beyer, Brooklyn, N. Y.
Albert H. Biertuempfel, Newark, N. J.
J. E. Black, Kansas City, Mo.
W. Black, Rutherford, N. J.
W. T. Blackburn, Paris, Ill.
Will P. Blair, Cleveland, O.
A. H. Blanchard, New York City
W. H. Boardman, Newark, N. J.
Frank J. Bock, Newark, N. J.
Mrs. Frank J. Bock, Newark, N. J.
E. P. Bogenhard, Newark, N. J.
Edward Bourleau, Chicopee, Mass.
T. H. Brannan, Columbus, O.
E. J. Brennen, Hastings-on-Hudson,
N. Y.

Charles C. Brown, Chicago, Ill.
Mrs. Helen A. Brown, New York City
Robert H. Brown, New York City
Benjamin F. Brooks, Kansas City, Mo.
F. H. Broodwell, Newark, N. J.
Walter Buehler, Chicago, Ill.
James B. Burnett, Newark, N. J.
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Second Annual Convention.....	1895..	Cincinnati, Ohio.
Third Annual Convention.....	1896..	Chicago, Ill.
Fourth Annual Convention.....	1897..	Nashville, Tenn.
Fifth Annual Convention.....	1898..	Washington, D. C.
Sixth Annual Convention.....	1899..	Toronto, Canada.
Seventh Annual Convention.....	1900..	Milwaukee, Wis.
Eighth Annual Convention.....	1901..	Niagara Falls, N. Y.
Ninth Annual Convention.....	1902..	Rochester, N. Y.
Tenth Annual Convention.....	1903..	Indianapolis, Ind.
Eleventh Annual Convention.....	1904..	St. Louis, Mo.
Twelfth Annual Convention.....	1905..	Montreal, Canada.
Thirteenth Annual Convention.....	1906..	Birmingham, Ala.
Fourteenth Annual Convention.....	1907..	Detroit, Mich.
Fifteenth Annual Convention.....	1908..	Atlantic City, N. J.
Sixteenth Annual Convention.....	1909..	Little Rock, Ark.
Seventeenth Annual Convention.....	1910..	Erie, Pa.
Eighteenth Annual Convention.....	1911..	Grand Rapids, Mich.
Nineteenth Annual Convention.....	1912..	Dallas, Texas.
Twentieth Annual Convention.....	1913..	Wilmington, Del.
Twenty-first Annual Convention.....	1914..	Boston, Mass.
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MEMBERSHIP LIST.

ACTIVE.

	Membership Dates From
Ackerman, J. Walter, Chief Engineer and Superintendent of Water Works, Auburn, N. Y.....	1905
Aldrich, Elbert C., City Engineer, Auburn, N. Y.....	1915
Aldridge, William, Chief Computer and Estimator, City Engineering Department, 333 McGee St., Winnipeg, Manitoba, Can.....	1912
Allen, F. R., City Engineer, Pine Bluff, Ark.	1911
Allen, Henry C., City Engineer, Syracuse, N. Y.	1917
Allin, Thomas D., Commissioner of Public Works, City Hall, Pasadena, Calif.	1905
Aloe, L. P., President Board of Aldermen, 513 Olive Street, St. Louis, Mo.	1917
Ambler, John N., Consulting Engineer for Winston, Winston, N. C.	1908
Anderson, Frederick J., City Engineer, City Hall, South Bend, Ind.	1915
Ash, Louis R., 1012 Baltimore Ave., Kansas City, Mo.....	1911
Ashley, Charles S., New Bedford, Mass.....	1912
Askwith, F. C., Deputy City Engineer, 203 Powell Ave., Ottawa, Ontario, Canada.	1916
Atwood, Joshua, Chief Engineer, Paving Service, Public Works Department, 501 City Hall Annex, Boston, Mass.....	1914
Babcock, C. E. P., Municipal Delegate From Buffalo, N. Y.....	1914
Baechlín, Ernest, Town Engineer, National Bank Building, Bloomfield, N. J.	1916
Baillairge, W. D., City Engineer, Quebec, Que., Canada.....	1912
Baker, Henry E., Consulting Engineer, Watertown, N. Y., now Hang Chow, Chekiang, China.....	1905
Ballinger, John E., Engineer of Highways, Jacksonville, Fla.....	1913
Barbour, Frank A., Consulting Engineer, 1120 Tremont Building, Boston, Mass.	1914
Barlow, James E., Director of Public Service, City Hall, Dayton, Ohio	1910
Barlow, John R., Montreal, Que., Canada.....	1910
Barrett, C. H., Mayor, Gloucester, Mass.....	1917
Bartholomew, Harland, Engineer City Plan Commission, Municipal Courts Building, St. Louis, Mo.....	1914
Bastis, Albert, Member City Council, Minneapolis, Minn.....	1917
Baylis, J. R., Bacteriologist, Montebello Filters, 3402 Harford Ave., Baltimore Md.	1911
Beggs, James L., Commissioner Streets and Public Improvement, 2049 N. Tremont, Kansas City, Kans.....	1915
Belt, Edwin K., Assistant City Engineer, 525 Woodward Ave., Kalamazoo, Mich.	1915
Benham, Webster L., Consulting Engineer, 13th Floor Colcord Building, Oklahoma City, Okla.	1916
Benzenberg, George H., 1310 Wells Building, Milwaukee, Wis.....	1894
Berry, George, Assistant Engineer, Bureau of Highways, Brooklyn, N. Y.	1905

Biertuempfel, Albert H., Commissioner, Board of Works, Newark, N. J.	1913
Bingham, Clarence A., General Manager, 271 Winter Street, Norwood, Mass.	1915
Blanchard, Arthur H., Professor of Highway Engineering, Columbia University, New York City.....	1909
Boudinot, Allen R., City Engineer, Davenport, Iowa.....	1914
Bourleau, Edward, Superintendent of Streets, 28 Pendleton Avenue, Chicopee, Mass.	1917
Bradshaw, H. J., City Engineer, Abilene, Texas.....	1912
Brandon, Walter W., Superintendent of Water Works, Anderson, Ind.	1915
Brannan, Thomas H., Superintendent Asphalt Construction, City Engineer's Office, Columbus, Ohio.....	1913
Brehm, George C., City Engineer, Waynesboro, Pa.....	1917
Brennan, W. C., Secretary City Corporation, Hamilton, Ont. Canada	1909
Briggs, B. E., Consulting Engineer, 508 Marine Bank Building, Erie, Pa.	1902
Brower, Irving C., Commissioner Public Works, 426 Hamilton St., Evanston, Ill.	1915
Brown, Charles Carroll, Consulting Engineer, Editor Municipal Engineering, 1648 Transportation Bldg., Chicago, Ill., and 702 Wulsin Building, Indianapolis, Ind.....	1895
Brown, Matthew, City Engineer, 211 S. State St., Emporia, Kans.....	1911
Brown, Thurber A., 416 E. Church St., Elmira, N. Y.....	1908
Brown, William M., Chief Engineer, Passaic Valley Sewerage Commission, 820 Essex Bldg., Newark, N. J.....	1913
Bryson, Carl H., City Engineer, City Hall, Lima, Ohio.....	1915
Buchanan, N. B., City Engineer and Secretary Tupelo Engineering Co., Tupelo, Miss.	1909
Bull, Irving C., Bull & Roberts, 100 Malden Lane, New York City	1912
Burke, G. W., Municipal Delegate from Pittsburg, Pa.....	1915
Caldwell, Wallace L., District Manager Pittsburg Testing Laboratory, 215 Clark Bldg., Birmingham, Ala.....	1913
Campbell, Edward F., Engineer for Pelham Manor and North Pelham, 230 Huguenot St., New Rochelle, N. Y.....	1916
Cannon, S. Q., Municipal Delegate from Salt Lake City, Utah.....	1915
Cappelen, F. W., City Engineer, Municipal Delegate from Minneapolis, Minn.	1895
Cardwell, William, Municipal Delegate from Essex County, N. J., 244 Rinshaw Ave., East Orange, N. J.....	1917
Carpenter, George A., City Engineer, Pawtucket, R. I.....	1905
Carson, H. O., City Engineer, 218-219 Odd Fellows Bldg., Butler, Pa.	1917
Carter, Hugh R., State Highway Engineer, New State Capitol, Little Rock, Ark.....	1909
Cellarius, Frederick J., 1001 Commercial Bldg., Dayton Ohio.....	1910
Charles, Frederick R., City Engineer, Richmond, Ind.....	1910
Chase, Guy H., Commissioner of Streets and Engineering, Fitchburg, Mass.	1917
Chaussé, Alcide, City Architect and Superintendent of Bldgs., 1433 Hubert St., Montreal, Que., Canada.....	1901
Christ, Edward H., Civil and Consulting Engineer, Norris Bldg., Grand Rapids, Mich.....	1908

Christy, E. A., Chief Architect, Building Division, City Engineers Office, Municipal Delegate, New Orleans, La.....	1917
Christy, L. V., Secretary Street and Sewer Department, Wilmington, Del.	1903
Clark, Alexander, Municipal Delegate from Essex County, N. J., 434 Scotland St., Orange, N. J.....	1917
Clark, Frederick H., Superintendent of Streets and Engineering, 328 Municipal Bldg., Springfield, Mass.....	1913
Codwise, Edward B., 298 Wall St., Kingston, N. Y.....	1906
Colle, C. E., Engineer for Green County Pike Commission and City Engineer for Greenville, Tenn.....	1916
Colby, Elmer E., City Engineer, Chickasha, Okla.....	1909
Collins, Clarke P., Sanitary Engineer, City Hall, Johnstown, Pa.....	1909
Collins, John L., Civil and Hydraulic Engineer, 30 Church St., New York City.....	1910
Collins, Thomas E., City Engineer, City Hall, Elizabeth, N. J.....	1916
Compton, R. Keith, Chairman and Consulting Engineer, Paving Commission, 214 E. Lexington St., Baltimore, Md.....	1915
Conant, Elbridge R., Chief Engineer, Savannah, Ga.....	1913
Condon, Pierce P., Superintendent of Streets, Watertown, Mass.....	1917
Connell, W. H., Chief Bureau of Highways and Street Cleaning, Municipal Delegate from Philadelphia, Pa.....	1914
Cook, J. C., Chief Engineer, The J. B. McCrary Co., Municipal Engineers, 1408 Third National Bank Bldg., Atlanta, Ga.....	1913
Cooksey, R. M., Municipal Delegate from Baltimore, Md.....	1914
Cooper, C. M., City Engineer, Columbus, Kans.....	1913
Cooper, C. Winston, Engineer for Winston County and for City of Fayetteville, Wilson, N. C.....	1915
Cornell, Douglass, Municipal Delegate from Buffalo, N. Y.....	1915
Corning, Dudley T., Assistant Engineer, Third Highway District, D. P. W., Bureau of Highways, Race and 15th Sts., Phila- delphia, Pa.	1909
Corson, S. Cameron, Boro Engineer, City Hall, Norristown, Pa.....	1908
Coward, E. H., Miners Savings Bank Bldg., Pittston, Pa.....	1916
Cowden, M. B., City Engineer, Municipal Delegate from Harris- burg, Pa.	1916
Cozzens, A. B., Secretary City Plan Commission, Firemen's Bldg., Newark, N. J.	1917
Craig, George W., City Engineer, City Hall, Calgary, Alberta, Canada	1911
Craver, H. H., Chief Chemist, Pittsburgh Testing Laboratory, Pittsburgh, Pa.	1914
Crayton, G. A., Civil Engineer, 213 Masonic Bldg., Lima, Ohio.....	1912
Crook, J. W., City Engineer, 1704 Lamar Ave., Paris, Tex.....	1912
Crosby, Walter W., Consulting Highway Engineer, 1431 Munsey Bldg., Baltimore, Md.	1909
Crowley, J. W., Commissioner Public Works, City Hall, Daven- port, Ia.	1917
Cummin, Gaylord C., City Manager, Jackson, Mich.....	1915
Curfman, Lawrence E., City Engineer, Pittsburg, Kans.....	1910
Currie, C. H., Consulting Engineer, Webster City, Ia.....	1917
Cutcheon, L. D., Secretary and General Manager, Board of Public Works, Grand Rapids, Mich.....	1906
Dallyn, Frederick Alfred, Provincial Sanitary Engineer, Province of Ontario, 137 Jeffrey St., Toronto, Ont., Canada.....	1916
Dalton, E. L., 9-10 Murphy Bldg., Dallas, Texas.....	1906

Darby, C. A., City Engineer, Sabetha, Kans.....	1915
Datesman, George E., Director, Department of Public Works, Municipal Delegate from Philadelphia, Pa.....	1916
Davis, Carleton E., Chief, Bureau of Water, Municipal Delegate from Philadelphia, Pa.....	1915
Davis, Charles H., South Yarmouth, Mass.....	1911
Davis, Charles O., Superintendent Street Sanitation, Milwaukee, Wis.....	1917
Dean, Arthur W., Chief Engineer, Massachusetts Highway Commission, 34 Oxford St., Winchester, Mass.....	1914
Dean, John A., Jr., City Attorney, Owensboro, Ky.....	1916
De Lay, Theodore S., City Engineer, Creston, Ia.....	1910
Denison, Henry S., Chairman Board of Public Works, Framingham, Mass.....	1917
Denman, A. R., Chairman, Department of Water, Board of Street and Water Commissioners, Kinney Bldg., 790 Broad St., Newark, N. J.....	1906
Devlin, F. E., City Engineer and County Surveyor, County Court House, Newton, Kans.....	1915
Devlin, Harry, Superintendent Buildings, Park Department, 2445 Valentine Ave., Bronx, New York City.....	1917
Dingle, James H., City Engineer, City Hall, Charleston, S. C.....	1908
Dorr, Edgar S., Chief Engineer Sewer Service, 213 Savin Hill Ave. (Dorchester), Boston, Mass.....	1913
Douthitt, M. J., City Engineer, City Hall, Waukegan, Ill.....	1911
Dow, A. W., Consulting Engineer, 181 E. 23rd St., New York City.....	1906
Drane, Frank P., Paving Inspector and Supervisor, 22½ W. 5th St., Charlotte, N. C.....	1913
Driscoll, Michael, Superintendent Streets and Sewers, Town Hall, Brookline, Mass.....	1914
Drowne, Henry B., 35 Kimberly Ave., Springfield, Mass.....	1912
Dubuc, Jules Henri, Engineer of Bridges and Subways, City Hall, Montreal, Que., Canada.....	1916
Duchastel, J. A., City Engineer, Outremont, Que., Canada.....	1917
Duck, Allen Douglas, City Engineer, Greenville, Texas.....	1913
Duff, Edward E., Jr., Boro Engineer, Municipal Bldg., Sewickley, Pa.....	1916
Durham, Henry Welles, Consulting Engineer, 366 Fifth Ave., New York City.....	1915
Durkin, Patrick, Superintendent of Public Works, 12 Mallory St., Danbury, Conn.....	1917
Dutton, E. R., Municipal Delegate from Minneapolis, Minn.....	1914
Eager, George, Municipal Delegate from Essex County, N. J., Millburn, N. J.....	1916
Earl, George G., General Superintendent, Sewerage and Water Board, New Orleans, La.....	1906
Eddy, Harrison P., Consulting Civil Engineer, 14 Beacon St., Boston, Mass.....	1914
Edgerly, R. J., City Engineer, Albany, Ga.....	1908
Eichelberger, F. O., City Engineer, 915 Cottage Grove Avenue, Dayton, Ohio.....	1915
Ellsworth, Frank V. P., Assistant City Engineer, San Antonio, Texas.....	1908
Elwood, F. T., City Engineer, Rochester, N. Y.....	1907

Emerson, C. A., Jr., Chief Engineer Pennsylvania State Department of Health, Harrisburg, Pa.....	1917
Erwin, M. C., San Antonio, Tex.....	1908
Estler, Charles E., Chairman Road Committee, Boonton, N. J.....	1917
Evers, Henry A., Councilman, 263 Pontiac Ave., Cranston, R. I.....	1917
Fellows, A. Lincoln, Consulting Engineer, 946 Equitable Bldg., Denver, Colo.	1918
Fetherston, John Turney, Engineer of Street Cleaning, Municipal Bldg., New York City.....	1911
Finch, B. K., City Engineer, Wilkes-Barre, Pa.....	1908
Finley, C. A., Municipal Delegate from Pittsburg, Pa.....	1915
Firth, Joseph, Superintendent Public Works, Charlotte, N. C.....	1908
Fisher, E. A., Consulting Engineer, City of Rochester, Rochester N. Y.	1896
Fisher, E. A., City Engineer, Lakewood, Ohio.....	1917
Fisk, George F., Assistant Engineer in Charge of Pavement Construction, Bureau of Engineering, Department of Public Works, 7 Municipal Bldg., Buffalo, N. Y.....	1916
Flenniken, John W., Commissioner Streets and Public Improvements, Knoxville, Tenn.	1912
Fletcher, Austin B., State Highway Engineer, Forum Bldg., Sacramento, Calif.	1912
Flood, Walter H., Consulting Chemical Engineer, 326 River St., Chicago, Ill.	1916
Folwell, A. Prescott, Editor Municipal Journal, 50 Union Square, New York City.	1901
Foreman, Alvah E., Assistant City Engineer, 1023 Oliphant Ave., Victoria, B. C.	1915
Fort, E. J., Chief Engineer of Sewers, Boro of Brooklyn, 1013-1014 Mechanics Bank Bldg., Brooklyn, New York.....	1905
Frankland, Frederick Herston, Bridge Engineer, Highway Department, Calcasieu Parish, Lake Charles, La.....	1914
Freitas, George H., City Engineer, Modesto, Calif.....	1913
Fugate, Harry C., City Engineer, West Palm Beach, Fla.....	1916
Fuller, George W., 170 Broadway, New York City.....	1906
Fulton, D. F., City Engineer, City Hall, Yonkers, N. Y.....	1914
Funk, Elmo A., City Engineer, City Hall, Anderson, Ind.....	1915
Gainey, W. H., City Engineer, Valdosta, Ga.....	1906
Gantz, M. A., Municipal Delegate from Troy, O.....	1914
Gault, Matthew, Superintendent of Sewers, City Hall, Worcester, Mass.	1917
Gaynor, Keyes C., 405 Frances Bldg., Sioux City, Ia.....	1911
Giddings, Fred, Consulting Engineer, 1104 Kirkman St., Lake Charles, La.	1896
Giles, John A., Commissioner of Public Works, City Hall, Binghamton, N. Y.	1911
Gillen, Charles P., Commissioner, Board of Street and Water Commissioners, City Hall, Newark, N. J.....	1914
Gillespie, Richard H., Chief Engineer Sewers and Highways, 286 E. 201st. St., Bronx, New York City.....	1912
Goff, Edward E., City Engineer, 17 Exchange St., Cranston, R. I.	1917
Goldstein, Harry I., Highway Inspector, Bureau of Highways, 4200 Woodland Ave., Philadelphia, Pa.....	1916
Goodell, John M., 106 Lorraine Ave., Upper Montclair, N. J.....	1904
Goodfellow, J. J., San Angelo, Tex.....	1912

Gorham, E. L., City Engineer, Lake Charles, La.....	1914
Gray, E. R., Acting City Engineer, City Hall, Hamilton, Ont., Canada	1916
Greenalch, Wallace, Commissioner of Public Works, Albany, N. Y.....	1908
Hackney, John W., Atlantic City, N. J.....	1908
Hallock, James C., Deputy Chief Engineer, City Hall, Newark, N. J.	1908
Hamley, S. J., District Manager, Pittsburgh Testing Laboratory, 242 Rockefeller Bldg., Cleveland, O.....	1917
Hammond, George T., Engineer of Design, Bureau of Sewers, 1013- 1014 Mechanics Bank Bldg., Brooklyn, New York.....	1908
Hamnett, W. S., Manager Pittsburg Testing Laboratory, 305 Prae- torian Bldg., Dallas, Tex.....	1912
Hansell, William A., Jr., Superintendent Public Works, Fulton County, 501 County Court House, Atlanta, Ga.....	1916
Hansen, Paul, Chief Sanitary Engineer, State Board of Health, Springfield, Ill.	1913
Hardee, W. J., City Engineer, and Chief Engineer Public Belt R. R., Municipal Delegate from New Orleans, La.....	1914
Harris, Harry F., County Engineer, Mercer County, N. J., Trenton, N. J.	1910
Harris, R. C., Municipal Delegate from Toronto, Ont., Canada....	1914
Harrison, Amos W., Municipal Delegate from Essex County, N. J., Mt. Pleasant Ave., Livingston, N. J.....	1916
Harrison, Edwin M., Director Department of Streets and Public Improvements, 31 N. Mountain Ave., Montclair, N. J.....	1917
Hatton, T. Chalkley, Sewer Commissioner, Milwaukee, Wis.....	1903
Haussling, Jacob, Mayor, Newark, N. J.....	1907
Hawley, John B., Hoxie Bldg., Fort Worth, Tex.....	1912
Hawley, John B., City Engineer, 614 Main St., Boonton, N. J....	1917
Hayler, Guy Wilfred, Senior Draftsman, Chief Engineer's Office, South Park Commission, Chicago, Ill.....	1914
Heebink, G. E., City Engineer, Goodwin Block, Beloit, Wis.....	1914
Heilman, Herbert W., Assistant Essex County Engineer, Newark, N. J.	1917
Helland, Hans, City Engineer, 1109 McCullough Ave., San Antonio, Tex.	1917
Henderson, Charles Elliott, City Engineer, St. Augustine, Fla....	1916
Hennen, Robert David, Engineer for County Commissioners, Mor- gantown, W. Va.	1913
Henry, P. W., 120 Broadway, New York City.....	1906
Hering, Rudolph, 170 Broadway, New York City.....	1910
Hermann, August, Cincinnati, O.....	1894
Hill, Curtis, Municipal Delegate from Kansas City, Mo.....	1914
Hill, Nicholas S., Jr., 100 William St., New York City.....	1911
Hills, George B., Engineer Manager, Isham Randolph & Co., Con- sulting Engineers, 1310 Heard Bank Bldg., Jacksonville, Fla.	1913
Hillyer, William R., Deputy Commissioner of Water Supply, Gas and Electricity for Boro of Richmond, New York City.....	1908
Hittell, John B., Civil Engineer, 5917 Winthrop Ave., Chicago, Ill.	1908
Hodgdon, J. B., Municipal Delegate from Joplin, Mo.....	1915
Hodges, Gilbert, Acting City Engineer, 230 S. Main St., Franklin, N. H.	1913
Hoffman, Robert, Chief Engineer Department of Public Service, Cleveland, O.	1908
Hohenstein, August, Purchasing Agent, City Hall, St. Paul, Minn.....	1914

Hoopes, Edgar M., Jr., Chief Engineer, Wilmington, Del.....	1915
Horner, W. W., Engineer of Design, Sewers and Paving, 325 City Hall, St. Louis, Mo.	1915
Horton, Irving S., 937 Washington St., Reading, Pa.....	1916
Howard, J. W., Consulting Engineer, Roads and Pavements, 1 Broadway, New York City.....	1901
Howe, Will B., City Engineer, Concord, N. H.....	1895
Howell, Carl L., Municipal Delegate from Buffalo, N. Y.....	1914
Howell, Robert P., Town Engineer, Phillipsburg, N. J.....	1908
Howell, William A., Engineer of Streets and Highways, City Hall, Newark, N. J.	1907
Hubbard, Prevost, Chemical Engineer, Chief, Division of Road Material, Tests and Research, U. S. Office of Public Roads and Rural Engineering, Willard Bldg., Washington, D. C.....	1913
Hudson, Leo, Consulting Hydraulic and Sanitary Engineer, 3265 Piedmont Ave., Dortmund, Pittsburgh, Pa.....	1912
Hughes, Hector James, Prof. Civil Engineering, Harvard University and Massachusetts Institute of Technology, 1-337 M. I. T., Cambridge, Mass.	1914
Hunter, Lionel McL., Roadway Engineer, City Engineer's Office, 20 Willard Ave., Ottawa, Ont., Canada.....	1916
Huston, R. C., Consulting Engineer, 1010 Falls Bldg., Memphis, Tenn.	1915
Hutchinson, A. E., Albuquerque, N. M.....	1915
Iredell, George S., Civil Engineer, Austin, Tex.	1908
Jennings, F. W., Village Engineer, Bixley, O., 509 Hartman Bldg., Columbus, O.	1915
Johnson, George A., Consulting Engineer, 150 Nassau St., New York City.	1917
Jones, Richard A., Superintendent of Streets, 27 Banks St., Walt- ham, Mass.	1917
Judson, William Pierson, Consulting Engineer, President Broadal- bin Electric Light and Power Co., Broadalbin, Fulton County, New York.	1902
Kappele, A. P., Secretary Works Department, City Hall, Hamilton, Ont., Canada.	1917
Kemper, Joseph, City Engineer, Utica, N. Y.....	1917
Kendrick, Julian, City Engineer, Birmingham, Ala.....	1898
Kennedy, W. E., Superintendent Streets and Sewers, 154 Benedict St., Waterbury, Conn.....	1917
Keyes, John M., Chairman Board of Road Commissioners, Chair- man Board of Health, Concord, Mass.....	1914
Kindrick, A. H., City Engineer, McAlester, Okla.....	1914
Kingsley, Edgar A., Consulting Engineer Roads and Pavements, 110 W. Dewey Place, San Antonio, Texas.....	1908
Kirkpatrick, Walter G., Municipal and Hydraulic Engineer, 703-704 Farley Bldg., Birmingham, Ala.....	1912
Kirschbraun, Lester, Consulting Engineer, 160 N. Fifth Ave., Chicago, Ill.	1909
Kistlet, Dr. J. M., Municipal Delegate, Minneapolis, Minn.....	1916
Klausmann, Henry W., Contracting Engineer, 1137-1138 K. P. Bldg., Indianapolis, Ind.	1912
Kleeberg, Felix, Chemist, Dept. of Public Works, Manhattan Boro, New York City	1915

Klyce, B. H., Box 312, Miami, Fla.....	1913
Knapp, N. A., Superintendent Highways, 38 Washington Ave., Greenwich, Conn.	1917
Kneale, Robert D., Consulting Engineer to Atlanta, Georgia, and Fulton County and State Highway Commissioner, Atlanta, Ga.....	1917
Knott, Francis B., 97 Wilsey St., Municipal Delegate from Essex County, N. J., Newark, N. J.....	1916
Kolner, C. W., General Manager and Electrical Engineer, Munici- pal Lighting Works, Municipal Delegate from Pasadena, Cal.....	1913
Kraemer, C. F., M. D., Commissioner Board of Works, City Hall, Newark, N. J.....	1913
Kraus, Jaros, Architect, Park Department, Flushing, N. Y.....	1917
Laberge, F. C., Consulting Engineer, 30 James St., Montreal, Que., Canada	1915
Lacombe, August L., Municipal Delegate from Essex County, N. J., 306 Lyon Ave., Irvington, N. J.....	1916
Lafaye, Edward E., Comm'r of Public Property, Municipal Delegate from New Orleans, La.....	1917
Lamb, Richard, Consulting Engineer, 90 West St., New York City.....	1917
Lanagan, Frank R., City Engineer, City Hall, Albany, N. Y.....	1913
Lawrence, E. A., City Engineer, Westerville, Ohio, 509 Hartman Bldg., Columbus, Ohio	1915
Lea, Lucian D., City Engineer, Lead, S. D.....	1912
Lee, B. M., City Engineer, Asheville, N. C.....	1908
Lee, W. Loring, City Engineer, Sumter, S. C.....	1916
Legare, T. Keith, City Engineer, Columbia, S. C.....	1916
Lenderink, Andrew, City Engineer, Municipal Delegate from Kala- mazoo, Mich.	1912
Levinson, Henry, City Engineer, Little Rock, Ark.....	1909
Lewis, Nelson P., Chief Engineer, Board of Estimate and Appor- tionment, Municipal Bldg., New York City.....	1895
Lewis, R. J., City Engineer, Fort Madison, Ia.....	1914
Linsley, Charles W., Commissioner of Works, 52 E. Utica St., Os- wego, N. Y.....	1915
Little, John C., Chief Engineer, The Roland Park Co., Roland Park, Baltimore, Md.	1910
Lovewell, Maurice N., Assistant Engineer, South Park Commis- sioners, 57th St., and Cottage Grove Ave., Chicago.....	1912
Luster, W. H., Elizabeth, N. J.....	1905
Lykken, H. G., Consulting Engineer, 1912 Midway, St. Paul, Minn.....	1910
Lyman, David Russell, Chief Engineer Board of Public Works, 214 City Hall, Municipal Delegate from Louisville, Ky.....	1913
Macallum, Andrew F., Commissioner of Public Works, Ottawa, Ont., Canada	1909
MacDonald, George E., Chairman Overseers of the Poor, Gloucester, Mass.	1917
MacDonald, James H., Road and Pavement Expert, New Haven, Conn.	1914
MacGregor, R. A., Assistant Engineer, Bureau of Highways, Man- hattan Boro, New York City.....	1915
Mackie, George D., City Engineer, Commissioner, City Hall, Moose Jaw, Sask., Canada	1916
Maetzel, Henry, City Engineer, Columbus, Ohio.....	1908
Magruder, J. O., City Engineer, Danville, Va.....	1911
Mangold, John F., City Engineer, Grinnell, Ia.....	1913
Marchant, Kilby I., Superintendent Streets, Gloucester, Mass.....	1917

Mattia, Richard F., Municipal Delegate from Essex County, N. J., 52 Summer Ave., Newark, N. J.....	1916
May, E. A., Engineer on Town and Village Improvements, Pat- chogue, L. I., N. Y.....	1917
McArthur, Franklin, City Engineer, Guelph, Ont., Canada.....	1916
McCabe, John C., Chief Inspector and Engineer, Department of Safety Engineering, 410 City Hall, Detroit, Mich.....	1912
McCalla, J. B., City Engineer, Knoxville, Tenn.....	1913
McCandless, Robert, Clerk, Street Department, 33 Chauncey Ave., New Rochelle, New York.....	1917
McCarthy, John, City Engineer, Wymore, Neb.....	1915
McCarthy, John J., Acting Purchasing Agent, Department Parks, 1149 75th St., Brooklyn, N. Y.....	1917
McCarthy, P. A., Consulting Engineer and City Engineer, Lufkin, Texas	1917
McClelland, Richard J., City Engineer, Kingston, Ont., Canada....	1917
McComb, Dana Q., Testing Engineer, Pittsburgh Testing Labora- tory, Miami, Florida	1917
McCoubry, Thomas, President Board of Aldermen, 51 Lemuel Ave., Chicopee, Mass.	1917
McCrary, S. K., City Engineer, 1011 Laramie St., Atchison, Kan....	1909
McLean, G. T., City Engineer, Astoria, Ore.....	1914
McMahon, Patrick F., Highway Commissioner, Brockton, Mass.....	1917
McMath, Robert E., 512 Bombard Ave., Webster Grove, Mo.....	1894
McNeal, John, Consulting Engineer and Contractor, Northampton National Bank Bldg., Easton, Pa.....	1911
Meade, R. E., 1600 Empire Bldg., Birmingham, Ala.....	1906
Meckley, Earle W., Principal Assistant Engineer, Department Streets and Public Improvements, City Engineer's Office, Al- lentown, Pa.	1914
Meigs, Joseph V., Chemist, City of Boston, Massachusetts Institute of Technology, Boston, Massachusetts	1917
Mercier, Paul E., Chief Engineer and City Surveyor, City Hall, Montreal, Que., Canada	1915
Meriwether, B. B., Care Birmingham Realty Co., Birmingham, Ala.	1908
Metz, L. V., Assistant to City Engineer, Erie, Pa.....	1910
Miller, B. F., Jr., City Engineer, 902 Grove St., Meadville, Pa.....	1910
Miller, Daniel J., Boro Engineer, Bangor, Pa.....	1916
Miner, Franklin M., Assistant Engineer, Street Laying Out De- partment, 404 City Hall Annex, Boston, Mass.	1913
Moore, John W., Consulting Engineer, 3342 N. Illinois St., Indian- apolis, Ind.	1915
Moorehouse, William B., Justice Peace, Member Town Board, Tarrytown, New York	1917
Morales, Luis, Chief Engineer Bureau Water Supply, Linea entre 6 y 8, Vedado, Havana, Cuba.....	1917
Morgan, L. T., City Engineer and Superintendent of Water Works, Box 43, Live Oak, Fla.....	1916
Morgan, R. D., City Engineer, Temple, Tex.....	1915
Morrison, Roger L., Professor of Highway Engineering, A. & M. College, College Station, Tex.....	1914
Morse, Howard Scott, Detroit Bureau of Governmental Research, 100 Griswold St., Detroit, Mich.....	1915
Moseley, Hal, City Engineer, Dallas, Tex.....	1915
Mullen, Charles A., Director Paving Department, Milton Hersey Co., Montreal, Que., Canada	1911

Murphy, M. D., Street and Sewer Director, Belvedere Apartments, Wilmington, Del.	1912
Myers, William G., City Engineer, Harrisonburg, Va.	1916
Naberhuis, H. A., 135 Tenth St., Miami, Fla.	1911
Near, W. P., City Engineer, St. Catherine, Ont., Canada.	1915
Nicholson, Maury, Assistant City Engineer, City Hall, Birming- ham, Ala.	1908
Nicholson, Victor, Engineering Chemist, City of Chicago, 7621 Lowe Ave., Chicago, Ill.	1914
Noble, O. E., City Engineer, Manhattan, Kans.	1908
Norton, George H., City Engineer, D. P. W., Municipal Delegate from Buffalo, N. Y.	1914
Ogden, Henry N., Professor of Sanitary Engineering, Cornell Uni- versity, Ithaca, N. Y.	1909
Ogier, James W., Assistant Engineer, City Engineer's Office, Bal- timore, Md.	1914
Olmsted, Frederick L., Landscape Architect, Brookline, Mass.	1909
Olroyd, Foster, City Electrician, Municipal Delegate from New Or- leans, La.	1917
Osgood, Manley, City Engineer, President, Washtenaw Engineer- ing Co., Ann Arbor, Mich.	1914
O'Toole, J. F., Municipal Delegate from Pittsburg, Pa.	1915
Owen, James, 196 Market St., Newark, N. J.	1904
Parent, Arthur, Superintendent City Lighting Department, Mon- treal, Que., Canada	1905
Parker, E. E., City Engineer, Madison, Wis.	1917
Parker, George A., Superintendent of Parks, Hartford, Conn.	1902
Parlin, Raymond W., Deputy Commissioner, Main Office, Depart- ment of Street Cleaning, Municipal Bldg., New York City.	1916
Parmalee, Louis R., City Engineer, Helena, Ark.	1913
Parobek, Anastasius, City Chemist, Trenton, N. J.	1914
Payton, Lyle, City Engineer, Moline, Ill.	1912
Peck, Leon F., Superintendent of Streets, Municipal Bldg., Hart- ford, Conn.	1913
Pennington, William, Municipal Delegate from Essex County, N. J., 32 Spruce St., Newark, N. J.	1916
Phul, William von, 2998 Pacific Ave., San Francisco, Cal.	1911
Pickersgill, H. M., Superintendent Public Works, Elmira, N. Y.	1917
Pierce, Herbert W., Commissioner Public Works, 26 City Hall, Rochester, N. Y.	1914
Pierson, Frank W., Street Commissioner, Wilmington, Del.	1915
Plunkette, J. L., City Engineer, Rome, N. Y.	1917
Pollard, Seabury Gould, Consulting Water Supply Engineer, 3422 Burch Ave., Cincinnati, O.	1915
Pollock, Clarence D., Consulting Engineer (Pollock and Taber), Park Row Bldg., New York City.	1902
Potter, Alexander, Consulting Civil Engineer, 50 Church St., New York City	1913
Preston, J. M., Dallas, Tex.	1908
Primeau, A. K., City Engineer, Muskegon Heights, Mich.	1916
Provost, A. J., Jr., 39-41 West 38th St., New York City.	1904
Prow, John C., City and County Engineer, Salem, Ind.	1909
Putnam, Charles E., Engineer, Boston Park and Recreation De- partment, 105 Hutchings St., Roxbury, Mass.	1916

Quinn, Edward W., 255 Lexington Ave., Cambridge, Mass.....	1913
Ramsey, J. E., Municipal Delegate from Salisbury, N. C.....	1915
Rankin, E. S., Engineer of Sewers and Drainage, Newark, N. J.....	1903
Redfern, Ira T., Village Engineer, South Orange, N. J.....	1916
Reimer, Frederic A., County Engineer, Essex County, Newark, N. J.....	1909
Reppert, Charles M., Division Engineer, Bureau of Construction, Department of Public Works, 5912 Douglas Ave., Pittsburg, Pa.....	1908
Reynolds, A. M., Chief Engineer, Essex County Commission, 60 Clifton Ave., Newark, N. J.....	1908
Rich, Edward D., State Sanitary Engineer, Lansing, Mich.....	1910
Richards, H. S., Assistant Superintendent, South Park Commis- sion, 6930 Constance Ave., Chicago, Ill.....	1909
Ridgway, Robert, Public Service Commission, 120 Broadway, New York City.....	1908
Roberts, H. N., Jr., City Engineer and Superintendent of Water De- partment, 2045 Main St., Longview, Tex.....	1915
Rogers, Nlart, City Engineer, Asbury Park, N. J.....	1909
Rolfe, William E., Associate to President of Board of Public Serv- ice, Municipal Delegate from St. Louis, Mo.....	1916
Root, Joseph E., Assistant Engineer, Division of Sewerage, 3436 Lyleburn Pl., Cincinnati, O.....	1915
Rowland, H. A., City Engineer, McPherson, Kans.....	1917
Rudolph, Charles A., Street and Sewer Director, 411 Delaware Ave., Wilmington, Del.....	1912
Russell, G. Raymond, City Engineer, 1624 Stimson Ave., Rosedale, Kansas.....	1915
Russell, L. M., City Engineer, 314 N. 2nd St., Elkhart, Ind.....	1913
Rust, Charles H., City Engineer, Victoria, B. C., Canada.....	1898
Ruttan, Colonel H. N., Consulting Engineer, 801-802 Confederation Life Bldg., Winnipeg, Man., Canada.....	1904
Ryan, Patrick H., Commissioner, Board of Street and Water Com- mission, City Hall, Newark, N. J.....	1915
Ryman, Ernest R., Municipal Delegate from Essex County, N. J., Director B. C. F., 206 Van Buren St., Newark, N. J.....	1916
Sammelmann, Sylverius, in charge Street Design Division, Depart- ment of the President, 5951 Julian Ave., St. Louis, Mo.....	1915
Sands, Edward E., City Engineer, City Hall, Houston, Tex.....	1914
Sargent, Welland F., Commissioner of Public Works, Municipal Bldg., Oak Park, Ill.....	1910
Sarver, William Edward, City Engineer, Canton, O.....	1915
Scattergood, E. F., Electrical Engineer, Department of Public Serv- ice, 1415 Berkshire St., R. F. D. 8, No. 331 A, Los Angeles, Cal.....	1913
Schmidt, H. H., Chief Engineer, Bureau of Highways, Room 502, 50 Court St., Brooklyn, N. Y.....	1915
Schmieder, Charles, Assistant Architect, Department Parks, 401 W. 50th St., New York City.....	1917
Shand, Gadsden E., Columbia, S. C.....	1908
Shaner, H. L., City Engineer, Municipal Delegate from Lynchburg, Va.....	1908
Shea, James B., Deputy Commissioner of Park and Recreation Commission of Boston, P. O. Box 108, Jamaica Plain, Mass.....	1916
Sheaf, Fred W., Municipal Delegate from Rutherford, N. J.....	1917
Shelton, William H., City Engineer, 617 Central Ave., Dunkirk, N. Y.....	1916

Shepard, Frank T., Town Engineer for Nutley and Belleville, Nutley, N. J.	1913
Sherrerd, Morris R., Chief Engineer, Department of Public Works, Newark, N. J.	1896
Sherron, George Austin, Street Commissioner and City Engineer, 178 Main St., Norwalk, Conn.	1917
Shipman, Charles M., General Superintendent of Works, Newark, N. J.	1905
Shockley, P. S., City Engineer and County Surveyor, News Bldg., Salisbury, Md.	1911
Simmons, Fred G., Commissioner Public Works, Milwaukee, Wis.	1917
Simons, F. F., Boro Engineer of Roosevelt, N. J., Carteret, N. J.	1917
Slattery, John L., Secretary-Treasurer St. Johns Municipal Council, Municipal Delegate from St. Johns, Newfoundland.	1901
Sloman, Arthur L., City Manager, Albion, Mich.	1917
Smith, A. P., Councilman, Boonton, N. J.	1917
Smith, Fred E., Surveyor Highways, Rockport, Mass.	1917
Smith, F. L., Assistant Engineer in Charge of Construction, Rochester, N. Y.	1915
Smith, Francis P., Consulting Engineer, 131-133 East 23rd St., New York City	1908
Smith, J. J., City Engineer, Grand Forks, N. D.	1913
Smith, Thomas W., Municipal Delegate from Essex County, N. J., 374 Bergen St., Newark, N. J.	1917
Smoot, L. D., Chief Engineer, Jacksonville, Fla.	1913
Snow, Hubert A., Chairman Highway Commission, 25 Rockland St., Brockton, Mass.	1917
Snyder, Frederick Antes, Chief Engineer, Town of Mount Royal, 230 St. James St., Montreal, Que., Canada.	1914
Sohier, William D., Chairman, Massachusetts Highway Commission, 15 Ashburton Place, Boston, Mass.	1914
Sparks, George W., President Street and Sewer Board, Wilmington, Del.	1912
Sprague, Norman S., Chief Engineer, Bureau of Engineering, D. P. W., Oliver Bldg., Municipal Delegate from Pittsburg, Pa.	1908
Stallings, Robert, State Bank Bldg., Little Rock, Ark.	1912
Starks, W. Fred, County Superintendent Highways, Glen Cove, New York.	1917
Steed, Robert E., City Clerk, P. O. Box 919, Norfolk, Va.	1911
Stern, Eugene W., Chief Engineer Highways of Manhattan, 21st Floor, Municipal Bldg., New York City.	1916
Stevenson, John D., Assistant Engineer, Bureau of Engineering, 1231 Monterey St., Pittsburgh, Pa.	1912
Strachan, Joseph, 352 Putnam Ave., Brooklyn, N. Y.	1905
Struthers, David L., City Engineer, Wilmington, N. C.	1915
Sullivan, James H., Division Engineer, Public Works Department, City Hall, Boston, Mass.	1913
Sumner, Charles R., City Engineer, Hermosa Beach, Calif.	1916
Swan, Jr., Abram, Engineer Streets, Municipal Bldg., Trenton, N. J.	1917
Sweetman, Emmett F., City Engineer, Urbana, Ohio.	1915
Sylvester, Elbert W., City Engineer and Superintendent Public Works, Poughkeepsie, N. Y.	1913
Talbot, A. N., Professor of Municipal and Sanitary Engineering, University of Illinois, Urbana, Ill.	1903
Talbott, H. M., City Engineer, Owensboro, Ky.	1914

Taylor, Alexander J., Engineer in Charge of Sewers, Wilmington, Del.	1908
Taylor, Henry C., Secretary Street and Sewer Department, Wilmington, Del.	1916
Taylor, W. H. Jr., Municipal Delegate from Norfolk, Va.	1917
Terry, Alfred H., City Engineer, City Hall, Bridgeport, Conn.	1917
Thayer, Joel A., Superintendent Streets, 386 Tremont St., Taunton, Mass.	1917
Thier, J. Ernest, Supervisor Roads, Montvale, N. J.	1917
Thomas, J. Fred, Boro Engineer, City Bldg., Farrell, Pa.	1912
Thompson, S. C., Principal Assistant Engineer, Bureau of Highways, Boro of Bronx, New York City.	1904
Thum, William, 123 Columbia St., Pasadena, Calif.	1912
Tillson, George W., Consulting Engineer to Boro President, Boro Hall, Brooklyn, N. Y.	1896
Tomlinson, W. S., Principal Engineer, Shand Engineering Company, Columbia, S. C.	1914
Tribus, L. L., 86 Warren St., New York City.	1908
Tries, William, Jr., Commissioner, Board of Street and Water Commissioners, City Hall, Newark, N. J.	1916
Truss, J. D., Commissioner Public Improvements, City Hall, Birmingham, Ala.	1917
Tuska, Gustave R., Consulting Engineer, 68 William St., New York City.	1915
Uhler, Wm. D., Chief Engineer, State Highway Department, Harrisburg, Pa.	1914
Ulrich, Edmund B., City Engineer, Reading Pa.	1914
Uppington, Sam F., Clerk Street Department, 182 Main St., New Rochelle, N. Y.	1917
Vandewater, J. A., Municipal Delegate from Buffalo, N. Y.	1914
Van Trump, Isaac, Consulting Asphalt Engineer, 2337 S. Paulina St., Chicago, Ill.	1911
Van Zuben, Frank J., City Engineer, Fort Worth, Tex.	1912
Varney, Henry A., Town Engineer, Town Hall, Brookline, Mass.	1916
Vars, Alexander, Town Engineer of Westfield, N. J., 814 Webster St., Plainfield, N. J.	1916
Vosler, Ray, 1044 Mercer St., Youngstown, Ohio.	1913
Waite, H. M., City Manager, Dayton, Ohio.	1912
Warman, H. S., Superintendent Weights and Measures, Boonton, N. J.	1917
Wasser, Thomas J., County Engineer, Court House, Jersey City, N. J.	1913
Waterman, F. V., Town Engineer, East Providence, R. I.	1917
Watson, Robert M., Boro Engineer, Rutherford, N. J.	1908
Weatherford, J. H., City Engineer, Memphis, Tenn.	1908
Weber, B. B., City Engineer, City Bldg., Oil City, Pa.	1917
Webster, George S., Director Department of Wharves, Docks and Ferries, Municipal Delegate from Philadelphia, Pa.	1914
Weirbach, Charles D., City Engineer, 702 N. 6th St., Allentown, Pa.	1916
Welborn, M. C., Chief Engineer of Sewers, Austin Tex.	1912
Weller, W. Earl, City Engineer, 16 Davis St., Binghamton, N. Y.	1916
Weston, Robert Spurr, Consulting Sanitary Engineer, 14 Beacon St., Boston, Mass.	1914

Wheeler, Holland, City Engineer, Lawrence, Kan.....	1905
Whipple, George C., 6 Berkeley Place, Cambridge, Mass.....	1905
White, Henry H., City Engineer, Muskogee, Okla.....	1917
White, Linn, Chief Engineer, South Park Commissioners, Chicago, Ill.	1908
Willigerod, William D., City Engineer, City Hall, East Orange, N. J.	1913
Willis, Thomas L., Engineer in Charge, Municipal Repair Plant, Municipal Delegate from New Orleans, La.....	1917
Wilson, James, County Commissioner and State Highway Commissioner, Court House, Wilmington, Del.....	1913
Wilson, W. H., 2833 Magnolia Ave., Park City, Tenn.....	1916
Wingfield, Nisbet, City Engineer and Commissioner Public Works, Augusta, Ga.	1906
Wise, B. A., City Engineer, Bradford, Pa.....	1916
Wise, Colin R., City Engineer, 301 Gregory St., Passaic, N. J.....	1915
Woodworth, C. A., City Engineer, Ida Grove, Ia.....	1916
Wooley, W. Thomas, City Engineer, Schenectady, N. Y.....	1915
Wulff, Edward J., Consulting and Constructing Engineer, Tarrytown, N. Y.	1917
Young, Alexander R., City Engineer, Topeka, Kans.....	1911

AFFILIATED.

Adam, Carl F., 1495 W. Adams St., Los Angeles, Calif.....	1914
Bureau of Municipal Research, 261 Broadway, New York City....	1915
Campbell, John, Superintendent Special Service Department, The Edison Electric Illuminating Company, 39 Boylston St., Boston, Mass.	1913
French, R. DeL., Principal Assistant Engineer, R. S. and W. S. Lea, Consulting Engineers, 820 New Birks Bldg., Phillips Square, Montreal, Que., Canada.....	1915
Gould, J. W., DuB., 30 Church St., New York City.....	1913
Greenough, Maurice Brown, in Charge Highway Engineering, Case School of Applied Science, Cleveland, Ohio.....	1915
Hegarty, D. A., Texas Southern Electric Company, 417 Commercial Bank Bldg., Houston, Tex.....	1913
Kopf, C. J., Boonton, N. J.	1917
Lloyd, Alfred O., Secretary Chamber of Commerce, Chester, S. C.....	1916
Lothrop, G. W., Woonsocket, R. I.....	1913
MacKenzie, L. R., Consulting Engineer and Contractor, Clayton, Mo.	1916
Masury, Alfred F., Chief Engineer, International Motor Company, 345 W. 70th St., New York City.....	1917
Routh, James W., Chief Engineer, Rochester Bureau of Municipal Research, 25 E. Main St., Rochester, N. Y.....	1916
Sawin, George A., Electrical Engineer, Public Service Electric Company, 759 Broad St., Newark, N. J.....	1914
Shakman, James G., Consulting Engineer, 5013 Grand Blvd., Chicago, Ill.	1916
Sheridan, L. V., C. E., Landscape Architect, 61 Oxford St., Cambridge, Mass.	1915
Soutar, Frank F., Consulting Engineer, 500-509 United Bank Bldg., Sioux City, Ia.	1915
Teesdale, Clyde H., in Charge of Wood Preservation, Forest Products Laboratory, Madison, Wis.	1914

Von Schrenk, Hermann, Tower Grove and Flad Aves., St. Louis, Mo.	1914
Webster, Edwin R., Consulting Municipal Engineer, Webster Bldg., Chicago, Ill.	1916
Wise, Henry A., Engineer Kansas City Stock Yards, Kansas City, Mo.	1917

MUNICIPAL MEMBERS.

BUFFALO, N. Y.

George H. Norton.
C. E. P. Babcock.
J. A. Vandewater.
Carl L. Howell.
George F. Fisk.

NEW ORLEANS, LA.

E. A. Christy.
W. J. Hardee.
Edward F. Lafaye.
Foster Olroyd.
Thos. L. Willis.

NEWARK, N. J.

Board of Chosen Freeholders of
Essex County, N. J.
George Eager,
Millburn, N. J.
Ernest E. Ryman,
Francis B. Knott,
Richard F. Mattia,
William Pennington,
Thomas W. Smith,
Newark, N. J.
Amos W. Harrison,
Livingston, N. J.
August L. Lacombe,
Irvington, N. J.

NEW YORK CITY.

Eugene W. Stern.
R. A. MacGregor.
Felix Kleeberg.

NORFOLK, VA.

W. H. Taylor.

PASADENA, CAL.

Municipal Lighting Dept.,
C. W. Kolner, Mgr.

PHILADELPHIA, PA.

George E. Datesman.
George S. Webster.
Carleton E. Davis.
Wm. H. Connell.

HARRISBURG, PA.

M. B. Cowden.

JOPLIN, Mo.

J. B. Hodgdon.

KALAMAZOO, MICH.

Andrew Lenderink.

KANSAS CITY, Mo.

Curtis Hill.

LOUISVILLE, Ky.

D. R. Lyman.

LYNCHBURG, VA.

H. L. Shaner.

MINNEAPOLIS, MINN.

Dr. J. M. Kistlet.
Albert Bastis.
F. W. Capellen.
Ellis R. Dutton.

ST. LOUIS, Mo.

Wm. E. Rolfe.

SALISBURY, N. C.

J. F. Ramsay.

SALT LAKE CITY, UTAH.

S. Q. Cannon.

ST. JOHN'S, NEWFOUNDLAND.

John L. Slattery.

TORONTO, ONT., CANADA.

R. C. Harris.

TROY, O.

M. A. Gantz.

UTICA, N. Y.

Joseph Kemper.

The following cities have memberships transferred from the Association for Standardizing Paving Specifications which have not yet been made use of:

Boston, Mass.

Pasco, Wash.

Columbus, O.

S. Omaha (now Omaha), Nebr.

ASSOCIATE.

- Adams, Arthur A., Contractor, Rep., Adams & Ruxbon Construction Co., Springfield, Mass.
- ADAMS & RUXBON CONSTRUCTION CO., Springfield, Mass....1914
Arthur A. Adams, Rep., Springfield, Mass.
- AMERICAN CAR SPRINKLER COMPANY, Worcester, Mass.....1917
E. D. Perry, Assistant General Superintendent, Worcester, Mass.
- AMERICAN CITY, THE, 93 Nassau St., New York City.....1913
Harold S. Buttenheim, Editor, 93 Nassau St., New York City.
- AMERICAN TAR CO., THE, 201 Devonshire St., Boston, Mass....1914
Charles P. Price, Manager, 201 Devonshire St., Boston, Mass.
- AMIES ROAD COMPANY, Drake Bldg., Easton, Pa.....1916
W. T. Newcomb, Consulting Engineer, Easton, Pa.
- ARABIA GRANITE COMPANY, 325 Connally Bldg., Atlanta, Ga..1917
Fred C. Mason, Secretary and Treasurer, Atlanta, Ga.
- Armstrong, Alexander F., Rep., Atlantic Refining Co., 3144 Passyunk Ave., Philadelphia, Pa.
- Arnold, J. H., Rep., Indian Refining Co., 17 Battery Place, New York City.
- ASPHALT AND SUPPLY COMPANY, Ltd., 103-7 Board of Trade Bldg., Montreal, Que., Canada.....1917
W. Alfred Morris, Engineer, Montreal, Que., Canada.
- ATLANTIC REFINING COMPANY, 3144 Passyunk Ave., Philadelphia, Pa.1914
A. F. Armstrong, 3144 Passyunk Ave., Philadelphia, Pa.
- ATLAS COMPANY, THE, Lincoln, N. J.....1915
W. W. Dixon, Lincoln, N. J.
- ATLAS PORTLAND CEMENT COMPANY, THE, 30 Broad St., New York City.1914
Wilbur T. Challar, Manager Road Department, 30 Broad St. New York City.
- BAKER, JOHN, JR., 17 Battery Place, New York City.....1911
John Baker, Jr., 540 Otis Bldg., 10 S. LaSalle St., Chicago, Ill.
Wm. H. Kershaw, Manager Eastern Division, 17 Battery Place, New York City.
Dennis A. Kennedy, Manager New England Division, 701 Tremont Bldg., Boston, Mass.
Walter L. Hempelmann, Engineer, 540 Otis Bldg., 10 S. LaSalle St., Chicago, Ill.
James T. Ware, Manager Western Division, 212 Dwight Bldg., Kansas City, Mo.
C. F. Hepburn, Manager Middle West Division, 540 Otis Bldg., 10 S. LaSalle St., Chicago, Ill.
H. E. Lersch, Manager New Orleans Office, 606-607 Hibernia Bank Bldg., New Orleans, La.
T. H. Reed, Manager Southern Division, 1802 American Trust and Savings Bldg., Birmingham, Ala.

- J. J. Gartland, Jr., Manager Richmond Office, 1126 Mutual Assurance Society's Bldg., Richmond Va.
- Baker, John, Jr., Rep., John Baker, Jr., 10 S. LaSalle St., Chicago, Ill.
- Baker, W. D., Rep., Warner-Quinlan Asphalt Co., 79 Wall St., New York City.
- BARBER ASPHALT PAVING COMPANY, THE, Land Title Bldg., Philadelphia, Pa.1918**
 Charles W. Bayliss, Philadelphia, Pa.
 Clifford Richardson, 233 Broadway, New York City.
 C. N. Forrest, New York Testing Laboratory, Maurer, N. J.
 G. R. March, Philadelphia, Pa.
 J. S. Miller, Maurer, N. J.
- Barbour, J. G., Secretary, Metropolitan Paving Brick Co., Canton, O.
- BARRETT CO., THE, 17 Battery Place, New York City1906**
 M. J. Beistle, Cleveland, O.
 Phillip P. Sharples, 17 Battery Place, New York City.
 S. R. Church, 17 Battery Place, New York City.
 B. M. Smith, Otis Bldg., Chicago, Ill.
 Edward C. Sargent, 428 Nellston St., Columbus, O.
- Bayliss, Charles W., Rep., Barber Asphalt Paving Co., Land Title Bldg., Philadelphia, Pa.
- Beistle, M. J., Rep., The Barrett Company, Cleveland, O.
- Bell, Philip, Manager Road Oil Department, Magnolia Petroleum Co., Box 1671, Dallas, Tex.
- BESSEMER LIMESTONE COMPANY, Youngstown, O.1911**
 Blackburn, W. T., Consulting Engineer, Dunn Wire-Cut-Lug Brick Co., Paris, Ill.
- BLACKMER & POST PIPE CO., Boatmens Bank Bldg., St. Louis, Mo.1912**
 C. H. Miller, St. Louis, Mo.
- Blair, Will P., Secretary, National Paving Brick Manufacturers Association, 828-834 Brotherhood of Locomotive Engineer's Bldg., Cleveland, O.
- BOOTH BROTHERS & HURRICANE ISLE GRANITE COMPANY, 208 Broadway, New York City1917**
 Charles Mitchell, Treasurer, New York City.
- BOSTON ROMAN ROAD COMPANY, 6 Beacon St., Boston, Mass..1914**
 William J. Clark, 6 Beacon St., Boston, Mass.
- Bramley, M. F., Rep., Cleveland Trinidad Paving Co., 420 Lakeside Ave., Cleveland, O.
- Brooks, Benjamin, Engineer, International Clay Products Bureau, 204 New York Life Bldg., Kansas City, Mo.
- Budge, Guy G., Rep., Warren Bros. Co., Grand Forks, N. D.
- BUFFALO STEAM ROLLER COMPANY, Box 990, Buffalo, N. Y. .1905**
 Jeffers F. Richardson, Sales Manager, Box 990, Buffalo, N. Y.
- Buttenheim, Harold S., Editor, The American City, 93 Nassau St., New York City.
- Carter, Zenas W., Secretary, Granite Paving Block Mfrs. Asso- of U. S., 54 Devonshire St., Boston, Mass.
- Challar, Wilbur T., Manager Road Department, Atlas Portland Cement Co., 30 Broad St., New York City.
- Cherrington, Frank W., Chief Engineer, Jennison-Wright Co., 2833 Scottwood Ave., Toledo, O.

- Church, S. R., Rep., The Barrett Co., 17 Battery Place, New York City.
- Clark, William J., Rep., Boston Roman Road Co., 6 Beacon St., Boston, Mass.
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- PIERCE OIL CORPORATION, St. Louis, Mo.1914
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- R. W. Sanders, 17 Battery Place, New York City.
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